Economics of Columbia River Initiative

Draft Report for review by the Washington Department of Ecology and the Economics Advisory Committee.

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EXECUTIVE SUMMARY

The purpose of this study is to review the economics of water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI is designed to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington state. The economic analysis in this report is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the state has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations. Consequently, this report focuses on the economic consequences of increased water diversions in the mainstem Columbia river in Washington State, including effects on agricultural production, municipal and industrial water supplies, hydropower generation, flood control, river navigation, commercial and recreational fishing, regional impacts, and passive use values. In addition to gauging these effects, the report includes a summary of issues related to the increased use of market transactions in water rights.

The analysis is focused on a series of five "Management Scenarios" developed by the Department of Ecology in consultation with water users. Roughly 4.5 million acre-feet of water is currently diverted from the Columbia river in the State, with 91% going to irrigated agriculture and 9% to municipal, industrial, domestic and other users. As shown in Table E-1, the first three Scenarios envision increasing these water rights by 1 million acre-feet (MAF) and permitting the interruptible rights (roughly 1% of the surface water rights) to be converted to non-interruptible rights. For each of these three Scenarios, the new water rights holders must meet water efficiency standards (called Best Management Practices, or BMPs) and begin metering their withdrawals. In Scenarios 2 and 3 fees are charged ($10 or $20 per acre-foot per year) for new and converted water rights, and 300 KAF of the 1 MAF is withheld until the majority of existing water users meet the BMPs. Scenario 4 envisions no overall increased in water diversions but it permits new users to obtain rights via transfer from existing users, thus mitigating for the new diversions in time and place. Scenario 5 is the "no change" or *status quo* option.

To evaluate the economic effects of second and third scenarios we developed lower level, partial allocations of the 1 MAF. These reflect the possibility that either the BMP & metering requirements or the increased fees would discourage new water applicants and keep the total new

Table E-1. Five CRI Management Scenarios

Scenario	Quantity of New Water Rights	Fees	Contingencies	Other Requirements
1	1 MAF	none	none	Meet BMPs and meter withdrawals
2	1 MAF	$10/acre-foot annually	300 KAF depends upon 80% of existing rights complying with BMPs	Meet BMPs and meter withdrawals
3	1 MAF	$20/acre-foot annual	300 KAF depends upon 80% of existing rights complying with BMPs	Meet BMPs and meter withdrawals
4	None	$30/acre-foot for transfers & conversions	New withdrawals must be fully offset by transfers, conservation or new storage.	Meet BMPs and meter withdrawals
5	Status Quo	none	Issuance of new rights follows current procedure & depends upon opinion of fishery managers.	

water rights allocation below the maximum of 1 MAF. For Scenario 2, the lower level was set at 700 KAF and for Scenario 3 the lower level allocation is set at 568 KAF. In assessing the impacts of these scenarios, we assume that the new water rights include 220 KAF for the Columbia Basin Project, 80.7 KAF goes to existing applicants for municipal and industrial water, and the remainder goes to agricultural users. We distribute the new agricultural water among river reaches and counties in a manner reflecting the locations of applications in the existing pool of water permit applications at DOE.

A major impact of the first three scenarios occurs in the irrigated agriculture sector, where new water rights allow the expansion of crop production, mainly in the Columbia Basin Project area and in Benton Country. Assuming that crop prices remain at current levels, and assessing the costs of crop production by use of crop budget studies, the gross revenue (sales value) and net revenue (sales revenue minus farm costs) of new crops was estimated for each of the Scenarios. The main results, detailed in Table E-2, are that agricultural production will increase with the new water allocations to generate between $169 and $485million in gross revenue, which corresponds to between $18.2 and $57.8 in net revenue by farms. Most of the new crop production occurs in Benton, Douglas, Grant, and Okanogan Counties. A 73% share of the new revenue is attributed to expansion in orchards, while 10.6% is in vegetables, and 6.4 % in potatoes. Under Scenario 4, we would expect some increase in value of agricultural crops as water is transferred from lower-valued to higher-vales uses. We did not estimate the magnitude of that increase.

Table E-2. Summary of Effects on Agricultural Production and Value

Scenario	Gross Revenue	Net Revenue
1	$485 mil.	$57.8 mil.
2	$339 - 485 mil.	$37.1 mil. -$57.8 mil.
3	$169 – 485 ml.	$18.2 mil - $57.8 mil.
4	unknown but likely >0	unknown but likely >0
5	none	none

Because the Municipal and Industrial (M&I) use of water is a relatively small portion of the total withdrawals from the river, and because these uses tend to have relatively high values, we assume that these uses are higher priority than agriculture. So, we did not attempt to place an economic value on M&I, but rather estimated a nominal increase for these uses. Based upon the fact that existing M&I applications represent about 28.5% of existing M&I water rights, and that the population in the Tri-City area has grown about 32% over the past 10 years, we chose the simple assumption that M&I water use would need to increase by 30% over the period covered by the CRI process. This amounts to 80.7 KAF, which will go to high-value uses and will facilitate the expansion of towns and food processing companies in the area where agricultural production is expected to grow.

Each new diversion will decrease the stream flow in the Columbia river downstream of the diversion point. This reduced flow will cause a reduction in hydroelectric power production at 6 Federal and 5 Public Utility District dams on the mainstem of the Columbia river. Using upon a simple monthly model of irrigation water withdrawal and return flow, and assuming hydropower production rates (megawatt-hours per unit of flow) remain as in the past, we estimate that the total loss of hydropower associated with an increased water withdrawal of 1 MAF will amount to between $9.4 million (for typical water years) and $9.7 million (for dry years). We have valued the hydropower using prices forecasted for the near future by analysts at the Bonneville Power Administration. The prices used do not take into consideration price increases that might occur in years of water shortage and high power demand.

Flood control and river navigation are important purposes served by the Federal dams in the lower Columbia and Snake rivers. The new CRI water diversions are not expected to have any effects on flood control activities, because the diversions will occur mostly during May – August, while flood control is a major factor in river operations only during the late winter and early spring high run-off period. Shallow draft river navigation (barging) occurs in the reservoir system from Bonneville dam to the Tri-cities area, and up the Snake River as far a Lewiston, Idaho. Barging is not expected to be significantly affected because reservoir levels are maintained to exceed levels necessary for lockage at dams even in dry years. Deep-draft navigation in the lower Columbia River below Bonneville dam is not expected to be affected by the new diversions, because the minimum flow needed to maintain the shipping channel depth (70 kcfs) will not be jeopardized by the small decreases in flow caused by a 1 MAF diversion.

Commercial and recreational fishing may be harmed by the increased diversions if the salmon and steelhead runs in the Columbia and Snake rivers are negatively affected. This would occur if mortality during downstream migration of juvenile fish, or upstream migration of adult fish, increases as flows decline. Lacking a scientific consensus on flow-mortality relationships, and considering that the National Research Council committee is evaluating the risks to salmon and steelhead, we did not attempt to quantify the possible economic loss. Instead, the report summarizes existing information about the economic values of fish caught in the commercial and recreational fisheries for Columbia river fish. Those values can be used at some point in the future to value the estimated change in anadromous fish runs.

When the agriculture sector expands, all related economic sectors (e.g. suppliers and food processors) are expected to expand in unison. Further, the increased incomes by wage-earners in the expanding sectors will spur increased sales of a wide variety of consumer goods, and this will cause yet additional economic expansion in the regional economy. To assess the regional economic impacts, we first estimate the “direct impacts” which encompass the increased sales of raw and processed agricultural products. Next, we assess the full effects, considering the expanding related sectors and income-driven economic expansion of the whole economy. These economic impacts are reported in three categories: Gross Sales or Output, Employment, and Value-Added. The Output impact measures the change in sales of all products, including raw materials, wholesale products, and retail sales. Employment is calculated from that Output impact by dividing the sales in each of 62 sectors in the State economy by a standard ratio of full-time employees per $1 mil of sales. Finally, the value-added (sales minus purchases of inputs) in each sector is summed up to yield a measure that is similar to regional income. As displayed in Table E-3, the most important figures are the total employment and total value-added for each level of water diversion. To put these numbers in perspective, these impacts are relatively modest in comparison to statewide totals of $222 billion in Gross State Product in 2001 and the 3.1 million in the State workforce in 2002. Still, these impacts represent roughly a 20% expansion in the State's agricultural economy. These impact assessments are likely a bit on the high side because they do not incorporate the likely price-depressing effects of increased agricultural production.

Table E-3 Summary of Economic Impacts of Agricultural Sector Expansion ($ millions)

	Output		Employment		Value-Added	
	Direct	Total Impact	Direct	Total Impact	Direct	Total Impact
1 MAF	$1223.7	$2,826.1	12,247	29,869	$559.6	$1345.3
700 KAF	$856.7	$1,974.1	8,569	20,864	$391.7	$939.5
569 KAF	$431.0	$993.9	4,300	10,496	$196.9	$473.0

Passive use values are held by the public for all manner of economic goods, services, and conditions. Sometimes called "existence values", these represent the amount people would be willing to pay for something even if they don't plan to consume or use it. Passive use values are thought to be particularly significant for public goods that are unique and scarce. Salmon and steelhead populations in the Columbia river qualify as objects having passive use values. We reviewed economic studies that estimated values for salmon in the range of $66.28 to $268.08 per fish. The wide range of estimates reflects both variability due to the vagaries of research methods in common use and variability associated with different descriptions of the “good” to be valued (e.g. a single endangered fish run, or a basin-wide complex of species). Like the commercial and recreational fishing values, these passive use value estimates may be applied to reductions in run size that are estimated to occur as a result of the prospective new water diversions.

Finally, we reviewed the prospects for water markets, which are an increasingly attractive alternative to regulatory or other non-market mechanisms for resolving disputes over water use and for improving the efficiency of water use. By permitting willing sellers and willing buyers to transfer water, markets will generally shift water from lower valued to higher valued uses. Three types of transactions can accomplish this result. Outright purchases of permanent water rights, temporary leases of diversionary water rights, and transfers of ownership of stored water (typically in a storage reservoir) all facilitate the increase in value of water use. While numerous water transfers of all types have occurred in Washington State, the expansion of water markets is slowed by three obstacles:

1. Third party effects of water transfer, due to shifts in return flows, have to be taken into consideration, possible involving compensation or mitigation.
2. Partly due to third party impacts, the water right that can be transferred needs to be defined in terms of consumptive use, not diversionary right, and this requires documentation and measurement that may not be immediately available.
3. There is often resistance to transfer of water from a traditional use (e.g. agriculture) to another use because of impacts on local communities and cultural attachments to traditional uses.

None of these is a fatal complication, but all three issues highlight the care required in development of a water transfer institution. Washington State has made the legal changes necessary to permit water transfers. Current law requires that such transfers be submitted to the DOE for review and approval. The ability to retain water rights while temporarily transferring water use to instream flow has also been achieved in Washington. The Washington Water Trust has purchased and leased water for enhancement of instream flows in such places as Salmon Creek, a tributary of the Okanogan river. And the DOE has a water acquisition program designed to shift water from out-of-stream use to instream flow in chosen locations. All these examples illustrate the principle that increasing transferability of water rights can, given adequate attention to the three issues listed above, work to improve economic efficiency of water use and to improve stream flows.

CONCLUSION

The Columbia River Initiative promises to encompass a number of important developments in the economy and environment of Washington's portion of the Columbia river. While considering increased diversions of water of up to 1 million acre feet, the CRI "management scenarios" also incorporate improved water efficiency and metering requirements, and they propose levying fees for new water users of $10 to $30 per acre-foot per year, with the fee level depending upon the level of threat to salmon runs. The economic review shows that these increased diversions are (a) unlikely to have significant impacts on flood control or river navigation, (b) will have moderately large negative impacts on hydropower production, (c) will have large positive impacts on the agricultural economy and on the regional economy that encompasses agriculture, and (d) might have some negative effects on fisheries and passive use values tied to salmon and steelhead runs. To some degree, the fees proposed under the second and third management scenarios will permit the State to mitigate the effects of increased water diversion on the fish and wildlife resources. Finally, improving and facilitating the exchange of water rights among users through water markets should improve the efficiency of water use and provide opportunities to acquire water for use by fish and wildlife.

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CHAPTER 1. INTRODUCTION

A. Columbia River Initiative (CRI) Rationale and Timeline

The purpose of this study is to review the economics of water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI has been proposed as a way to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington State. The analysis completed herein is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the state has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations.

Through the CRI process the state is seeking to develop an integrated state program that will allow access to the river's valuable water resources while at the same time providing support for salmon recovery. In recent years, competition for water from the river has continued to escalate. There is little agreement on the stream flows needed to support salmon survival. Hundreds of pending applications exist for new diversionary water rights from the Columbia. Litigation has been used increasingly to try to drive public policy in widely divergent directions, but often has resulted only in additional conflict and legal bills for the parties involved. The purpose of the CRI is to establish a scientific basis for a state water management program for the Columbia River that can meet the needs of salmon populations while supporting the region's economy. The CRI will result in a policy that defines how the Department of Ecology (Ecology) will carry out its dual obligations of allocating water and preserving a healthy environment.

Ecology has proceeded with the CRI by forming two review committees: an economics review and a national science review. The economics review, the subject of this report, seeks to understand the economic value of water from the mainstem of the Columbia River. It will provide information about how Washington benefits from water allocations, including allocations required in protecting salmon runs. The science review will be conducted by the National Academy of Sciences (NAS) and will consist of a formal, independent review of the science of fish survival and hydrology in the Columbia River. As a part of the science review, regional scientists have been asked to help inform the NAS committee by providing information and perspectives at two public meetings. The Department of Ecology will use the information generated by both the science and economic reviews to help develop a new water resource management program for the mainstem of the Columbia River.

The timeline for the economic review calls for the completion of the project by the end of the 2003 calendar year. A draft of the study is to be submitted in November 2003. Interested and affected parties will then comment on the draft, the study team will revise the draft, and the final review will be submitted in December 2003. Once all information regarding the CRI has been collected, Ecology will adopt a final rule in late 2004.

B. Water Rights on the Columbia River in Washington: Magnitude and Pending Applications

In response to the endangered species listing for salmon a moratorium was placed on new diversions from the Columbia River in 1991. The moratorium was lifted in 1998 and a rule implemented requiring Ecology to consult with fish agencies before authorizing new appropriations of Columbia River water. Ecology began to process a few water right applications that had been filed before the moratorium was declared. In the fall of 2001, Ecology was set to issue the water rights specifying conditions based on information from the National Marine Fisheries 2001 biological opinion. However, early in 2002 a Benton County Superior Court judge issued an order restraining Ecology from authorizing new rights.

There are currently 754 existing surface water (SW) rights accounting for slightly more than 4.5 million acre-feet (MAF) per year along the Columbia River in Washington State. An application pool exists for SW rights accounting for slightly more than 600 thousand acre-feet (KAF) along the Columbia River in Washington State. Ground water (GW) rights and applications also exist; with GW rights accounting for about 470 KAF and GW applications accounting for 183 KAF. Some of the rights in existence are interruptible. An interruptible right is a right that Ecology can choose not to recognize during a low water year, so that less water will be diverted, leaving more water for in-stream uses. Washington irrigators with water withdrawal permits issued after 1980 are subject to interruption when the water supply forecast at The Dalles Dam falls below 60 MAF from April through September. For SW rights, less than 1% of diversions are of interruptible status accounting for 39 KAF. For GW rights, 10.5% of diversions are of interruptible status accounting for 89 KAF.

Of the existing SW rights, 69% of the diversions occur at Grand Coulee pool, 13% at John Day pool, and 12 % at McNary pool. The remaining 6% of diversions are spread across the remaining 8 pools.

Of the existing SW rights, 91% of the diversions are for irrigation purposes, 5% are for commercial & industrial use, 2% are for domestic & municipal use, and 2% are for other purposes. A summary of existing SW rights and applications for SW rights from the Columbia River is shown below.

Table 1.1. Columbia River Existing Diversionary Rights and Pending Applications by Pool in Acre-feet

Pool	SW Rights	SW Applications
Bonneville	3,854	0
John Day	587,000	138,446
The Dalles	421	260,172
McNary	561,024	138,964
Priest Rapids	9,842	0
Rock Island	94,143	6,149
Wannapum	13,401	1,847
Rocky Reach	44,354	7,710
Wells	64,556	53,859
Chief Joseph	27,350	741
Grand Coulee	3,157,664	650
Total	4,563,608	608,540

C. Management Scenarios

The following is an introduction to the management scenarios developed by Ecology for the Columbia River Initiative. The scenarios represent a range of water management strategies, and they relate to levels of risk to salmon from allocating additional water rights from the Columbia River mainstem. Chapter 2 begins with a more detailed explanation of the scenarios, how the study team will interpret them, and what assumptions will be made.

Scenario 1 assumes that the risk to salmon is low, and allows for 1 MAF of new diversions from the Columbia River per year over a 20 year period. Interruptible water rights can be converted to uninterruptible if irrigators conform to Best Management Practices (BMPs) as determined by Ecology. All new water rights issued would also require BMPs and would also be metered. This requirement carries over to scenarios 2 through 4. There will be no fees on new diversions and scenario 1 assumes that the current level of mitigation is adequate.

Scenario 2 assumes a low to medium risk to salmon, and allows initially for 700 KAF of new diversions, and later 300 KAF more after the majority of users (80% of total diversions) conform to BMPs. Interruptible rights can be converted to uninterruptible as in scenario 1. New and converted rights are subject to a fee of $10 per AF, with generated funds to support a new level of salmon restoration.

Scenario 3 assumes a medium risk to salmon, with the potential for new rights identical to that of scenario 2. The associated fee for new and converted rights is $20 per AF, and the revenue generated will contribute to an even more robust salmon restoration, new conservation, and the exploration of storage development.

In scenario 4, the risk to salmon is considered to be medium to high, and new diversions will only be allowed if they are offset in proportion to consumption. Essentially, all new rights would offset existing water use through transfers, conservation, and/or new storage. Conversion to uninterruptible is still possible by adhering to BMPs, and new and converted rights pay a fee of $30 per AF, with the funds used to acquire mitigation water in low water years and habitat improvement in the mainstem and tributaries.

Finally, scenario 5 assumes that the risk to salmon is high, and that the potential for new diversionary rights and the conversion of interruptible rights would be based on the opinion of fish managers. No fees exist for any future diversions, and mitigation would be explored on a case-by-case basis. This scenario represents the status quo.

CHAPTER 2. COLUMBIA RIVER INITIATIVE "MANAGEMENT SCENARIOS"

As a part of the science review being conducted by the National Academy of Sciences, Ecology developed a set of five alternative management scenarios specifying different levels of risk to salmon that might result from the diversion of water from the Columbia River. In general, the management scenarios include conversion of interruptible status to non-interruptible status, mitigation funding, mitigation measures, and potential for new water rights. The scenarios reflect a range of potential water resources management strategies for the Columbia River mainstem. It is important to emphasize that the Department of Ecology will not finalize the features of a final management program for the Columbia River until the results of the National Academy of Sciences study are understood.

In order to assess the magnitude of the economic impacts of the five scenarios, it is necessary to attempt to quantify the effects of each scenario through extrapolation. The extrapolation used in this study is based on a pool of existing Washington State water permits, certificates, and applications within one mile of the mainstem.

A. Risk to Salmon

Determining the risk to salmon is the task of a review currently underway by the National Academy of Sciences (NAS). The NAS review is not due to be completed until early next year, and because of this, cannot be incorporated in the scope of the economic impacts study. Instead, Ecology has provided a spectrum of possibilities regarding the risk to salmon, and for that reason a level of risk is assumed by this study team, but again, the true assessment of risk will be determined by NAS. Below is a table showing the intended risk to salmon of each scenario.

Table 2.1. Risk to Salmon by Scenario

Scenario	Risk to Salmon
1	Low
2	Low to Medium
3	Medium
4	Medium to High
5	High

B. Mitigation Funding

In scenarios 2, 3, and 4, the Department of Ecology has proposed an option designed to generate the revenue necessary to implement mitigation measures necessary to offset the effects of water use. A financial contribution per acre-foot of water associated with both new rights and the conversion of a right from interruptible to uninterruptible status. Scenarios 1 & 5 do not contemplate this kind of funding mechanism. A summary of the contributions per acre foot of water use for new rights and/or rights converted from interruptible to uninterruptible is outlined below.

Table 2.2. Fees by Scenario

Scenario	Fee per Acre-Foot
1	$0
2	$10
3	$20
4	$30
5	$0

C. Conversion of Interruptible Rights to Uninterruptible Rights

Under each of the scenarios, current holders of interruptible water rights would be provided an opportunity to convert to uninterruptible rights. An interruptible right can be directed to discontinue water withdrawals from the river during a drought year. Washington irrigators with water withdrawal permits issued after 1980 are subject to interruption when the water supply forecast at The Dalles Dam falls below 60 MAF, from April through September, as it was in 2001. Approximately 330 existing water rights on the Columbia River were issued subsequent to the adoption of the instream flow rule. The conversion of the right to uninterruptible would be permitted if the irrigator adheres to BMPs for irrigation efficiency as outlined by Ecology, and pays the related fee per acre-foot of water for the associated scenario as described in the previous section.

A water use efficiency program has been designed jointly by the Columbia Snake River Irrigators Association (CSRIA) and Ecology to help define what BMPs are. The two organizations agreed to develop the program as an option for irrigation and M&I water users with rights issued after 1980 to convert their rights to an uninterruptible status. All newly issued rights would also be subject to BMPs. The proposed BMPs vary according to the number of acres being irrigated. If a water user has fewer acres, the BMPs would be less expensive and simpler to implement compared to the BMPs of larger users. The efficiency program classifies existing water right holders into three sectors, with appropriate BMPs associated with each water user sector: Small Public Sector Irrigation, Other Small Irrigation, and Large Irrigation. The BMPs for water management and operation cover diversion and distribution systems, application systems and technology, crop and water management, new research, development and demonstration projects, and benefits for fish, wildlife, and environmental resources. In exchange for conversion to uninterruptible, the draft rule would require that water saved as a result of implementing the BMPs be transferred to Ecology or its designee for placement in the state's trust water right program. For more details on the water use efficiency program and BMPs, see the Appendix A at the end of this document.

Assuming that all interruptible rights could potentially convert to uninterruptible status provides an upper bound for the amount of revenue created if an irrigator adheres to the BMP and pays the fee. Below is a summary by pool of the amount of water that is currently interruptible. Assuming that all irrigators meet the requirements for conversion, and multiplying the fee by the amount of water allows for an extrapolation of the revenues created by each scenario.

Table 2.3. Interruptible SW Rights by Pool

Pool	Acre-Feet of Interruptible Rights	% of Total
Bonneville	0	0%
John Day	31,651	26%
The Dalles	24	0%
McNary	51,647	43%
Priest Rapids	0	0%
Rock Island	8,491	7%
Wannapum	721	1%
Rocky Reach	1,914	2%
Wells	24,316	20%
Chief Joseph	1,111	1%
Grand Coulee	415	0%
Total AF	120,641	100%

Apparently, about 69% of the interruptible rights in terms of acre-feet exist at McNary and below, and roughly 29% occur above McNary. Applying the total number of acre-feet to be converted from interruptible to uninterruptible status to the associated fee allows for extrapolation of potential State revenues. This table is shown below. The table below does not yet account for potential revenues collected from the issuance of new rights.

Table 2.4. Potential State Revenues (Upper Bound) by Scenario

Scenario	Fee	Revenue
1	$0	$0
2	$10	$1,206,408
3	$20	$2,412,816
4	$30	$3,619,224
5	$0	$0

D. Mitigation Measures

Each of the scenarios outlines mitigation measures to be undertaken, based on the risk to salmon. For scenario 1, the current recovery efforts are assumed to be adequate, and Ecology would perform periodic assessment of the state's new water management program for the Columbia River to accommodate changes over time. Additionally, water transfer institutions would be encouraged.

Scenario 2 includes all of mitigation actions covered by scenario 1. In addition, the funds collected for new rights and converted rights would be used to support new levels of salmon restoration. The use of funds would be prioritized by fishery managers.

In addition to measures taken in the first two scenarios, scenario 3 would provide a more robust contribution to salmon health and survival. The state would provide financial support for new conservation and actively explore storage development.

For scenario 4, the generated funds would additionally be used to acquire mitigation water in low water years.

Scenario 5 would allow mitigation measures to be determined on a case-by-case basis in consultation with fisheries managers. Scenario 5 represents the status quo, and can be considered the "no action" scenario required by the State Environmental Policy Act.

E. Potential for New Water Rights

Lastly, each of the scenarios outlines the potential for increased diversions of Columbia River SW for use in Washington State. In scenario 1, where risk to salmon is low, Ecology will allow for the largest amount of increased diversions, and each subsequent scenario allows for more stringent rules governing the issuance of more diversions. Scenario 1 allows for new permits to be issued by the State during a 20-year window, not to exceed 1 MAF in total. Of that 1 MAF, up to 220 KAF could be allocated to the Columbia Basin Project. On top of the 1 MAF set aside for use in Washington State, 427 KAF would be legally recognized by the state to remain in the Snake River for in-stream uses, to supplement instream flow and address temperature issues. In addition to the 1 MAF and 427 KAF allocations described above, 600 KAF from the mainstem of the Columbia would be recognized as necessary to meet the needs of Oregon State.

Consider the following for scenario 1, in which future SW diversions are extrapolated from existing SW permits, certificates, and applications provided by Ecology. Assume that Ecology grants all existing SW applications accounting for approximately 348 KAF.[1] Further assume that Ecology grants 652 KAF of future applications to total 1 MAF of additional Columbia River diversions. Of the 652 KAF in future applications, the Columbia Basin Project has a claim to 220 KAF of water from Grand Coulee pool. Subtracting this from the 652 KAF in future applications leaves about 432 KAF for Ecology to distribute in new water rights. Lastly, we assume permits granted to new applicants are distributed among reservoirs the same as current applications, and the total of the future applications granted to equal 432 KAF.

Diversionary water rights can be used for a variety of different purposes. The majority of SW diversions occur for irrigation purposes along the Columbia River. The BPA estimates that 90% of the total water withdrawn in the Pacific Northwest is for irrigation. The BPA also estimates that 8% of diversions are shared by domestic, municipal, and industrial uses.[2]

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[1] This is based on cubic feet per second (cfs) as stated on the application multiplied by 1.98 Acre Feet per 1 cfs, multiplied by 183 days (6 months) for an irrigation season. This amount excludes the application from Klickitat PUD for about 260 KAF from The Dalles pool.

[2] BPA, 1993

To summarize municipal & industrial (M&I) use for rights within one mile of the Columbia River, about 93 KAF of water, or about 2.0%, is used for municipal uses; while about 244 KAF, or about 5.3% is used for industrial use[3]. When considering applications for water, the relative amount of water for M&I purposes increases. Of the applications for M&I water within one mile of the Columbia, about 69 KAF, or 11.4%, is for municipal uses; while about 7.5 KAF, or 1.2%, is for industrial uses. The relatively large application pool for municipal water might reflect the increasing demands for water in rapidly developing areas.

In order to determine the increasing needs of municipalities along the Columbia we will look at population trends in the counties relevant to the study. Under ideal conditions, the study team would like to examine actual M&I water use along the Columbia River. However, data on M&I use are not readily available. Thus, we will look at M&I water rights and applications along the Columbia as a proxy of M&I water use.

The Tri-Cities is the most important urban center for M&I use of Columbia River water. The area is surrounded by three counties: Benton, Franklin, and Walla Walla. Current diversionary rights allow for 269 KAF in the three counties near the Tri-Cities, and the combined population of the 3 counties is 247 thousand. Furthermore, applications exist for the three counties summing to almost 77 KAF, a 28.5% increase over existing M&I water rights.

It seems logical to conclude that the growth in population for an area would drive the need for water. The population of the three counties relevant to the Tri-Cities area has increased by 32.9% from 1990 to 2000. Extrapolating linearly suggest a rather large growth rate for the next 10 to 20 years between 32.9% and 65.8%. Recent trends suggest that growth rates are falling off in Washington State mostly due to the stagnant economy.[4] Population growth numbers will likely come back as the economy continues to recover, but are unlikely to hit the levels of the booming 1990's. Therefore, a good population increase for the Tri-Cities area might lie somewhere between 30% and 45% about 20 years ahead.

Suppose population growth over the next 20 years is 30% reflecting steady economic growth over the same period. During the same 20 years, the window for new rights in Washington will be open and we would expect the water needs of the area to increase by the

[3] Ecology specifies uses as Domestic/General & Municipal and Commercial & Industrial. The first category is essentially "Municipal" and the second category is essentially "Industrial."

[4] Washington State Office of Financial Management website

same amount over the same time period. Thus, water needs will increase by 30% from there current level. The current pending applications in the Tri-Cities area call for a 28.5% increase in M&I water, and we'd expect to see the difference between 30% and 28.5% to be applied for sometime in the future. Thus, a total 1.5% of current M&I water from of the 3 counties relevant to the Tri-Cities will be applied for in the future and will follow the same distribution as current pending applications.

Water Rights for M&I use account for only 8% of the total increase in diversions, which is consistent with the BPA's findings in 1993. To determine the amount of water going into agriculture, the study team assumed that diversions will only occur for irrigation purposes or M&I purposes. Thus, the increases in diversions for irrigation were found by subtracting diversions for M&I from the total diversions by pool or by county. A small number of diversionary applications exist for "Other" purposes, which might include uses such as livestock, mining, and thermoelectric. These applications were ignored because they account for less than one percent of the total.

A few notes regarding the below extrapolation. The extrapolation ignores the application at the Dalles pool from Klickitat PUD for power totaling all 260 KAF of water applied for. In addition, the Columbia Basin Project (CBP) has a claim to 220 KAF of the future water withdrawals, all of which will be taken out of Banks Lake from the Grand Coulee pool and used for irrigation purposes. The remaining 432 KAF of future water rights will be distributed as the pending applications are distributed. For example, the total amount to be taken out of Grand Coulee includes 220 KAF for CBP plus 806 AF for existing applications. This extrapolation of the distribution of future SW rights is shown in Table 2.5.

The extrapolation considered above can be summarized in other ways, such as future water rights by county or future water rights by WRIA. Depending on the analysis for a particular section, the study team may need to consider the extrapolation in different ways. For example, the extrapolation should be considered by pool for the hydropower section of the report, because different flows at different pools will allow for different amounts of power to be generated by letting water flow through turbines.

Table 2.5. Extrapolation of Future Water Rights by Pool, in acre-feet

Pool	Current Applications		Extrapolation of Future Applications		
	Irrigation	M&I	Irrigation	M&I	Total New Rights
Bonneville	0	0	0	0	0
The Dalles	0	0	0	0	0
John Day	131,244	7,202	171,165	371	309,982
McNary	69,368	69,596	168,595	3,583	311,143
Priest Rapids	0	0	0	0	0
Wanapum	1,847	0	2,289	0	4,136
Rock Island	6,149	0	7,619	0	13,768
Rocky Reach	7,710	0	9,553	0	17,264
Wells	53,859	0	66,732	0	120,591
Chief Joseph	741	0	919	0	1,660
Grand Coulee	650	0	220,806	0	221,456
Total AF	271,570	76,798	647,678	3,954	1,000,000

The extrapolation might want to be considered by county in the irrigated agriculture section, because different counties generally have different conditions and soils and will therefore have different crop mixes. For illustrative purposes, the extrapolation of scenario 1 organized by county is shown below. In this table, the 220 KAF of water recognized to the CBP comes out of Banks Lake in Grant County.

Table 2.6. Extrapolation of Scenario 1 by County

County	Current Applications		Extrapolation of Future Applications		
	Irrigation	M&I	Irrigation	M&I	Total New Rights
Benton	181,616	65,085	302,315	3,351	552,368
Chelan	12,250	0	15,178	0	27,429
Douglas	25,110	0	31,112	0	56,222
Ferry	0	0	0	0	0
Franklin	7,805	5,203	15,850	268	29,126
Grant	0	0	220,000	0	220,000
Kittitas	0	0	0	0	0
Klickitat	9,565	5	11,857	0	21,427
Lincoln	0	0	0	0	0
Okanagon	32,947	0	40,822	0	73,768
Stevens	650	0	806	0	1,456
Walla Walla	1,626	6,504	9,739	335	18,204
Total AF	271,570	76,798	647,678	3,954	1,000,000

There are various distributional concerns regarding additional water withdrawal and the issuance of additional water rights. For example, ignoring return flow, diverting all 1 MAF/year from one pool during a short period of time of the year might have a noticeable effect on river levels downstream from that particular pool, and therefore might have significant negative impacts on the Columbia River system downstream from the point of diversion. Nonetheless, Ecology will need to take care in granting permits to applicants as the distribution of diversions is a very important consideration. As a practical matter the required short term spike in withdrawals with a sufficient magnitude to significantly effect downstream flows is unlikely to occur. It seems more likely that variability in flow volumes would be absorbed within the operation of the Federal Columbia River Power System. It is also important to note that the 1 MAF will be appropriated gradually over a 20 year period, so it is unlikely that all additional water withdrawals will be diverted in the first year. This will allow Ecology to be prudent in its decisions to allow further withdrawals after the initial issuance of new water rights to applicants.

Scenarios 2 and 3 are identical in the maximum amount of new water to be made available: 1 MAF. However, they differ in structure of issuance and fees for new and converted rights. In these two scenarios, new permits would be issued during a 20-year window, not to exceed 700 KAF. Later, after users have demonstrated that state-of-the-art efficiency practices (BMPs) are in place for "the majority" of water users (defined by Ecology as 80% of users); the state will issue an additional 300 KAF. Fees for new and converted rights will be $10/AF and $20/AF for scenarios 2 and 3, respectively. Economic principles suggest that as some constraint becomes more severe (i.e. fees or BMPs), a consumer will mitigate the damages by consuming less (i.e. choosing not to apply for water). Therefore, it is unclear whether water applicants will find it in there best interest to conform to BMPs and pay the related fee. It is also unclear whether current water right holders will find it beneficial to conform to BMPs so that the additional 300 KAF will be issued. This suggests that there may be some upper and lower bound on the amount of water to be issued for scenarios 2 and 3.

As an upper bound, extrapolation of these scenarios will be identical to the procedure for scenario 1, only the last 300 KAF will not be issued until BMPs have been demonstrated. The upper bound will assume that water users and interruptible right holders find it in their best interest to conform to BMPs and the remaining 300 KAF will be issued. Additionally, new and converted water users will incur costs associated with investment in BMPs and the fee paid to the state for their water. This will result in reductions in net income to irrigators and M&I users relative to scenario 1. That is, the increase in the value of production will be $10 million ($10/AF times 1 MAF) smaller than that of scenario 1. The $10 million will be transferred to the state, as will the $1.2 million for converted rights (see Table 2.4). Similar assumptions will be made for scenario 3, with a total of 1 MAF of additional water rights at $20/AF, totaling $20 million transferred from irrigators to the state, and $2.4 million for converted rights.

The low-level is more difficult to predict. Because water is a commodity less fungible than other traded commodities, it is unclear to what degree users will mitigate the damages of price increases. Both scenarios require that new and converted users must comply with BMPs and pay the associated fee. Under these conditions, we may not see enough water demand to take the initial 700 KAF, or even the amount of current applications plus water to be allocated to the CBP, totaling about 568 KAF.

For scenario 2, the study team will assume as a low-level that sufficient demand exists to allow for the initial 700 KAF to be consumed. However, 80% of current water users and interruptible right holders do not find it in there best interest to adopt BMPs and therefore an additional 300 KAF is not issued. Alternatively, the low-level could reflect the notion that the increased costs associated with the proposed fees reduce the quantity demanded for new water such that there is insufficient demand for available water. This low-level will result in a transfer of $7 million from water users to the state. We will assume no water revenue to the state from the conversion of interruptible rights. Even here, this doesn't necessarily represent a lower bound on water allocations because of all costs incurred; it is simply what the study team will assume as a low-level assessment.

In order to extrapolate the low-level assessment, assumptions need to be made about the distribution of the new water across users. As was assumed above, the study team will allow for a 30% increase in M&I water needs reflecting the trend in population growth. We will assume that M&I water is generally higher valued and will likely receive a higher priority, and therefore, all existing and future applications will be granted rights. This accounts for almost 81 KAF—the same as that of scenario 1 and the upper bounds of scenarios 2 and 3. Additionally, all of the 220 KAF set aside for CBP will be distributed to irrigation by assumption. This leaves 399 KAF to be distributed across pools and counties as the pending applications are distributed. The tables below summarize the low-level assessment for scenario 2 by pool and by county.

Table 2.7 Low-level Assessment for Scenario 2 by Pool

Pool	Irrigation	M&I	Total
Bonneville	0	0	0
The Dalles	0	0	0
John Day	172,666	7,573	180,239
McNary	135,869	73,179	209,049
Priest Rapids	0	0	0
Wanapum	2,361	0	2,361
Rock Island	7,861	0	7,861
Rocky Reach	9,857	0	9,857
Wells	68,853	0	68,853
Chief Joseph	948	0	948
Grand Coulee	220,831	0	220,831
Total AF	619,248	80,752	700,000

Table 2.8 Low-level Assessment of Scenario 2 by County

County	Irrigation	M&I	Total
Benton	276,309	68,436	344,745
Chelan	15,661	0	15,661
Douglas	32,101	0	32,101
Ferry	0	0	0
Franklin	13,506	5,471	18,978
Grant	220,000	0	220,000
Kittitas	0	0	0
Klickitat	12,231	5	12,236
Lincoln	0	0	0
Okanagon	42,119	0	42,119
Stevens	832	0	832
Walla Walla	6,489	6,839	13,328
Total AF	619,248	80,752	700,000

Scenario 3 would have costs very similar to Scenario 2, except that the fees charged for new water rights rise to $20/acre-foot; this may discourage some prospective water uses. To provide a range of possible impacts, we consider a low-level assessment of new water rights allocation of 568 KAF, which equals the existing application pool, plus the proposed allocation of 220 KAF to the Columbia Basin Project. This lower bound is chosen to be below the 700 KAF lower bound adopted for Scenario 2, because the higher fee is bound to crowd out more low-valued water applications. Again, the extrapolation assumes first that all water for M&I

purposes will be granted corresponding to a 30% increase in water needs, and then that CBP will be granted its 220 KAF. The remaining 268 KAF of water will be granted to irrigators distributed as current applications for water are distributed. Tables 2.9 and 2.10 below summarize the low-level assessment for scenario 3 by pool and county respectively.

Table 2.9 Low-level Assessment of Scenario 3 by Pool

Pool	Irrigation	M&I	Total
Bonneville	0	0	0
The Dalles	0	0	0
John Day	129,333	7,573	136,906
McNary	68,358	73,179	141,538
Priest Rapids	0	0	0
Wanapum	1,820	0	1,820
Rock Island	6,060	0	6,060
Rocky Reach	7,598	0	7,598
Wells	53,075	0	53,075
Chief Joseph	731	0	731
Grand Coulee	220,641	0	220,641
Total AF	267,616	80,752	568,368

Table 2.10 Low-level Assessment of Scenario 3 by County

County	Irrigation	M&I	Total
Benton	178,972	68,436	247,408
Chelan	12,072	0	12,072
Douglas	24,745	0	24,745
Ferry	0	0	0
Franklin	7,692	5,471	13,163
Grant	220,000	0	220,000
Kittitas	0	0	0
Klickitat	9,425	5	9,431
Lincoln	0	0	0
Okanagon	32,467	0	32,467
Stevens	641	0	641
Walla Walla	1,602	6,839	8,442
Total AF	487,616	80,752	568,368

Scenarios 4 and 5 are identical in there potential (or lack thereof) for additional withdrawals. Scenario 4 assumes that additional withdrawals would be extremely damaging to salmon populations, and therefore no additional withdrawals will be granted unless they are directly supported by new storage. Any new rights granted would be required to offset water use through transfers, conservation, and utilizing new storage capacity. Scenario 5 is a no action scenario in which the existing rules governing the water resources of the Columbia River remain intact. Below is a table summarizing the potential for new water rights by scenario.

Table 2.8. Potential for New Water Rights by Scenario

Scenario	Potential for New Rights
1	1 MAF
2	700 KAF initially, 300 KAF in the future
3	700 KAF initially, 300 KAF in the future
4	Transfers, conservation, & new storage only
5	None

References

Bonneville Power Administration. 1993a. Modified Streamflows 1990 Level Irrigation, Columbia River and Coastal Basins 1928-1989. Portland, OR

CHAPTER 3. IRRIGATED AGRICULTURE

A. Summary of Impacts to Irrigated Agriculture

The allocation of new water rights is of significant interest to agricultural communities. As new technologies and crops are developed, growers find they are able to produce new crops on land that previously had not been very productive. Examples of crops that have emerged during the last decade include wine grapes, hops, new apple varieties, storage onions, sweet corn for processing, and fresh vegetables. There is also interest in producing more traditional crops. In this section we summarize the potential benefits of allocating more water rights out of the Columbia River to irrigated agriculture.

Recall that there are 3 management scenarios that result in increased SW diversions from the Columbia River. Scenario 4 involves directly offsetting mitigation measures through transfers and storage and scenario 5 examines the status quo. Therefore, neither of these scenarios contemplates the potential for new diversionary water. Additionally, scenarios 2 and 3 have been extrapolated to allow for a range of possible outcomes for which water users might react to different mitigation fees for water. Scenario 1 doesn’t call for fees for new water, and it is assumed that all of the potential water will be diverted. The only costs associated with scenario 1 are that new and converted water users are required to conform to BMPs. Therefore, there are essentially 5 extrapolations being considered: scenario 1, scenario 2 upper bound, scenario 2 lower bound, scenario 3 upper bound, and scenario 3 lower bound.

Scenario 1 serves as an upper bound for all scenarios. It assumes that the increased costs associated with conforming to BMPs do not reduce the demand for water or change the crop mix. Scenario 2 upper bound and scenario 3 upper bound will be identical to scenario 1 in the amount of new water withdrawn. The difference lies in the fees related to new water and the resulting reductions in the irrigator’s net incomes. These upper bounds also assume that the increased costs associated with fees for water and efficiency standards do not reduce the demand for new water. However, scenario 2 lower bound and scenario 3 lower bound assume that the increased costs associated with the new water do reduce its demand. These reductions in demand are monotonic downward in that scenario 3 lower bound has higher costs associated with it than scenario 2 lower bound and scenario 1.

To summarize the economic impacts of the scenarios, let us first examine the gross revenues for different crops across counties. Scenario 1 (and upper bounds for scenarios 2 and 3) lead to total gross revenue increases of just under $500 million. The largest county impact occurs in Benton County at about $260 million. The largest increase in gross revenue by crop group occurs with orchards at over $357 million. Consistent with this trend, the largest increase in gross revenues is for orchard lands in Benton County at about $175 million. The magnitude of changes in Benton County is drive largely by the water right extrapolation based on the number of existing rights. It is possible that enough high quality acreage does not exist to fulfill these estimates. The smallest impacts occur in Stevens County and for wheat. It is important to note that each of the tables includes acreage for irrigation only; M&I acreage has been subtracted off of the total. Table 3.1 summarizes the gross revenue impacts for the upper bound of Scenarios 1, 2 and 3.

The lower bounds for scenarios 2 and 3 offer increasingly smaller impacts on gross revenue associated with new water diversions. Scenarios 2 and 3 have total gross revenue increases of $339 million and $169 million, respectively. Identical patterns emerge in that the largest impacts occur in Benton County and for land in orchards. Lower valued crops such as wheat still show the smallest increases in gross revenues. Tables 3.2 and 3.3 summarize the gross revenues for the lower bounds of scenarios 2 and 3.

When considering revenue net of costs, we get a different perspective of the impacts to irrigated agriculture due to new water rights under the management scenarios. These figures give the return to water and management skill. As discussed in section 3.F., some net revenues are negative since the net revenues represent economic profits rather than cash or accounting profits. This means that all implicit (or opportunity) costs as well as all explicit (cash or accounting) costs are included. Production costs are higher when including opportunity costs leading to negative net revenues for low value crops. This represents the cost of producing crops if you were to enter the industry today without any farm equipment accumulated. Growers that have been producing for a period of time will have lower cash or accounting costs than those entering since they have accumulated equipment they no longer pay for out of pocket. This does not affect the gross revenue figures. Realize, however, that some crops would still be grown if they were losing money if they were grown to provide rotational benefits to high value crops. Total net revenues from Scenario 1 are just under $58 million. Only two lower valued crops, other and wheat yield negative net revenues. No counties have total net revenues yielding negative values. Recall that these impacts are also the upper bound for scenarios 2 and 3. Table 3.4 below summarizes the agricultural net revenue impacts.

For scenario 2 lower bound, negative net revenues become more frequent as acquiring new water becomes a more costly endeavor. The total impact on net revenues is a $37 million increase. The crop mix is slightly different for this scenario to account for the higher cost of water. There is a slight increase in high value crops and a decrease in low value crops. Hay becomes a crop that yields negative net revenues across all counties, and Stevens County yields overall negative net revenues for the crop mix considered in the region. Results are summarized in Table 3.5.

Lastly, consider net revenues for scenario 3 lower bound. Total irrigated agriculture impacts are $18 million. Negative values become the most frequent in this case, although no new crops or new counties yield overall negative values. Again, the crop mix for this scenario assumes more high value crop acreage and less low value crop acreage to reflect the response to the increase in water costs. Once again, recall that the negative net revenue does not necessarily imply that growers are producing at a loss. Rather, it indicates they are making less returns on equipment or management skills relative to the case with no water charges. Table 3.6 summarizes the results for scenario 3 lower bound.

B. Method of Analysis for Valuing Irrigated Agriculture

There are a number of methods for valuing the change in irrigated agriculture from a potential increase in water rights for Columbia River water. These methods range from indirect approaches, such as: comparing land values land with and without water rights; examining current water transfer prices; or direct methods such as valuing potential increases in cropping acreage.

The approach here will be to examine the quantity of water that is to be made available at what cost to irrigators and calculate the value of the likely crop mix for water based on existing data. In this sense the water allocation is driven by current water right applications rather than the economic value of water. To have water allocation driven by the economic value of water it would be necessary to develop an economic based linear programming model (or some other algorithm based model) of irrigated agriculture in Eastern Washington, which is beyond the scope of the present analysis.

Calculating the value of additional Columbia River water rights is a multi-step process as follows:

1. Estimate the water allocated to each county based on current water right applications for each scenario. This step was discussed above in section 2.E.
2. Determine which crops are likely to be grown with the potential water rights based on the county crop mix that currently use Columbia River water and crop rotations.
3. Determine the applied water per acre for each crop group and county.
4. Calculate the crop acres implied by the estimated water allocation (i.e. diversions to become applied water) and the resulting quantity of water for crop consumptive use. For example, suppose a water right that amounted to 900 acre-feet were granted, the system distribution efficiency were 65-percent, the appropriate crop mix consumptive use were 2 acre-feet, and the appropriate irrigation technology mix efficiency were 70-percent. The 900 acre-foot diversion right would support (900*.65)/(2/0.7) = 204.75 acres of irrigated agriculture. That indicates a figure of 0.23 acres/acre-foot of new water right.
5. Calculate the value of the increase in irrigated agriculture based on the per acre crop values by county and in total.

The data and methodology for each of these steps is discussed below.

C. Crop Mix by County (step 2)

One of the key components and challenges of valuing potential water allocations for irrigated agriculture is to identify the crop mix that uses Columbia River water in each county. There are a number of considerations and challenges. The main consideration is identifying which crops are likely to be grown with new water rights. One possibility is that primarily high value crops would be brought into production since it may not be cost effective to grow low value crops. This would certainly be the case in regions where the water would have to be lifted from the river over any significant elevation. However, this may not be the case if the water is diverted through existing irrigation canals where the marginal cost of delivering the water is low. Another possibility is that high value crops have already pushed out low value crops in many areas that would support them, leaving room in the market for new water to bring lower value crops into production. There is also a need to produce low value rotation crops with many of the high value vegetables. The result is that there is potential for both high and low value crops to be brought into production if new water rights are allocated. The assumption in this study is that the new crop mix being brought into production will be similar to the existing crop mix.

Finding the current crop mix still presents several challenges. First, counties do not keep a current record of how many acres of each crop are grown annually, making the current crop mix difficult to identify. Second, counties do not specify crop mix by water source. This is of particular concern for this analysis since the county crop mix that uses Columbia River water could be significantly different than the crop mix for the entire county. As such, we will begin by discussing what exactly Columbia River water is defined to be and to what degree each county depends on the Columbia. Then we will discuss the selected crop mix for each county in light of their dependence on the Columbia, which will take several steps.

For purposes of this study Columbia River water is defined to include surface water and groundwater within one-mile of the River. Groundwater within one-mile is considered to be hydrologically connected to the Columbia River by Ecology. The study area for irrigated agriculture consists of the regions that receive Columbia River water east of Bonneville Dam within Washington State. The Columbia River borders 13 counties in the study area, including: Stevens, Ferry, Lincoln, Okanogan, Douglas, Chelan, Grant, Kittitas, Yakima, Benton, Franklin, Walla Walla, and Klickitat. Columbia River water is also delivered to Adams County via cannels of the Columbia Basin Project.

The approach used to identify the crop mix that uses Columbia River water in each county is a three step process:

1. Begin with 1997 census data, the last complete account of crop acreage by county. This is given below in Table 3.7.
2. Update the 1997 census data according to additional county level data for specific crops and state level trends from the Washington Agricultural Statistics Service (WASS) Annual Bulletin.
3. Select the appropriate crop mix that uses Columbia River water for each county. This will be achieved by interviewing extension agents from each county or region.

This process gives a fair representation of the current crop mix that depends on Columbia River water. The 1997 census data presented in Table 3.7 is discussed in greater detail in Appendix B to this report. The second step involves updating the 1997 census data by examining a number of reports with county level data that were collected since the 1997 census was released. The additional reports were produced by the Washington Agricultural Statistical Service and are discussed in Appendix B. We need to make several assumptions to update the 1997 data. First, since there have been very few new water rights granted since the 1997 census, total acreage is assumed to remain constant or decline. Second, since there have not been any additional studies examining the Hay or Other crop categories; we allow those to adjust as needed to keep acreage constant. The remaining changes are discussed below.

Potato crop acreage was updated to year 2000 levels based on the WASS study discussed in Appendix B. Data was available for year 2001, however, since that was a severe drought year the year 2000 data was deemed to be more representative of current cropping patterns. The most significant changes were the increases in Benton, Franklin, Klickitat, Lincoln and Walla Walla counties. The remaining counties only showed small changes in potato acreage. The updated cropping acreage for potatoes and all the crop groups are shown in Table 3.8.

Updating wheat acreage was more difficult due to the inconsistency of the data available. Adams, Franklin, Grant and Walla Walla counties were updated to year 2000 levels. Benton, Douglas, and Lincoln counties were updated to 1999, as that was the most recent data. The data for the remaining counties were not changed. Discussion with the extension agents from the upper Columbia (Chelan, Ferry, Okanogan, and Stevens) confirmed that wheat acreage that depends on the Columbia River had not changed much during that time period.

The WASS gathered acreage data for many of the vegetable crops in the study. Similar to above, acreage was updated to year 2000 to avoid the drought effects of 2001. Though data was gathered for many different vegetables, data was not available for all vegetables. As such, the analysis assumes that the data gathered is representative of all vegetable crops. To update the data, the percentage change in the crops from 1997 to 2000 was calculated for each county and multiplied by the 1997 census data. For example, Adams County had a 245% increase in vegetable acreage, which was due primarily to an increase in asparagus and sweet corn. Similarly, Grant County had a six-percent decrease, which was due to a decrease in onions and sweet corn. This method was used for each county. Overall there was a ten-percent increase in vegetable acreage.

Orchard acreage was only gathered at the state level by the WASS. The approach to update orchard data was similar to that of the vegetable data. The percentage change in the crops from 1997 to 2000 was calculated for each county and multiplied by the 1997 census data. Overall there was sixteen-percent increase in orchard acreage during the period. There were a number of exceptions however. According to extension agents from the region including Chelan, Douglas, Ferry, Okanogan, and Stevens counties there was no real increase in orchard acreage. This was primarily because there was not much low value crop acreage that could be switched into orchards. As a result, orchard acreage data for these counties were not changed.

The third step is to identify the crop mix for each county that depends on the Columbia River. It is important to determine what type of crops the Columbia River water is used for relative to the rest of the county. That is, it may not be appropriate to assume the county wide crop mix in determining the value of Columbia River water if the various water sources serve areas of the county that differ significantly in what type of crops each area can produce. For example, the overall crop mix for Klickitat County indicates the primary crops to be irrigated are hay and pasture. However, many of the crops in Klickitat County that use Columbia River water include orchards and vineyards which are considered high value crops. Consequently, the value of Columbia River water used in Klickitat County is substantially higher than that of water for the overall county crop mix.

To determine the crop mix that depends on Columbia River water we first calculated the ratio of Columbia River water rights to irrigated acreage from the 1997 Census, as is shown in Table 3.9. This approach implicitly accounts for other irrigation water sources. If the ratio of water rights to irrigated acreage is high there are likely to be few alternative water sources. If the ratio is low, there are likely to be a number of alternative water sources. The weakness of using this approach ignores issues related to the difference between applied water (or diversions) and crop consumptive use, which is discussed below in the section on irrigation technology (step 3). The crop mix that is determined to depend on Columbia River water for each county is then used as a representative ratio of acreage to calculate the value of new water rights.

Benton, Douglas, and Grant counties use the Columbia River as their primary source of water, as is indicated by the high ratio of Columbia River water rights to irrigated acres in Table 3.9. Benton County also uses a significant amount of water from the Yakima River, however, the crop mix for both water sources is similar. The Columbia River is also the primary water source for Adams County, but it is not reflected in the ratios since the water is diverted by the Columbia Basin Project in Grant County. Consequently, the county level irrigated crop mix in these counties is likely to be representative of their Columbia River water crop mix, so no further adjustment is necessary. The crop mix for these counties given in Table 3.8 will be used to calculate the proportion of acreage using new agricultural water rights in these counties.

Chelan, Ferry, Klickitat, Okanogan, Walla Walla, and Stevens counties use Columbia River water, but not as their only or primary source. As such, it is necessary to verify whether the county level crop mix is representative of the crop mix that depends on Columbia River water. Extension agents for the Chelan, Ferry, Okanogan, and Stevens county region indicated that Columbia River water is used primarily for orchard crops in this area. As such, the crop mix for Chelan County that uses Columbia River water is represented by the data in Table 3.8. The appropriate crop mix for Okanogan County that depends on Columbia River water does not contain as much hay, wheat, vegetable and other crops as is indicated by the 1997 census data. Rather, the bulk of those crops are irrigated by the Okanogan River. Consequently, a crop mix similar to that of Chelan County is assumed to represent Columbia River water use for Okanogan County.

Franklin and Kittitas use very little Columbia River water relative to their other water sources. Unfortunately, little data was available on what the correct crop mix would be. As such, the figures in Table 3.8 are used to estimate the crop mix proportions. Yakima County uses such a small amount of Columbia River water that it is not considered as a potential user of new water rights in this analysis.

D. Irrigation Efficiency and Water Use (step 3)

The data available for determining conveyance and irrigation efficiency by crop and county is limited. Conveyance efficiency refers to the efficiency of moving water from the river to the field and irrigation efficiency refers to the efficiency of applying water to crops. For example, when an irrigation district conveys water from the Columbia River through one if its primary canals to a secondary canal they can expect to lose some water. The primary canal would be considered 85-percent efficient if for every 100 AF it diverted from the river, 85 AF made it the secondary canal. Conveyance efficiency is cumulative, so if the primary canal is 85-percent efficient and the secondary canal is 85-percnet efficient, the conveyance efficiency of those canals combined would be 72-percent (0.85 * 0.85 = 0.72). Conveyance efficiency ranges from below 40-percent to over 90-percent across the Columbia River basin. The low range corresponds to conditions where either the water is conveyed over a long distance, passing through many systems and/or conveyance systems with low efficiencies due to seepage and similar losses from the canal. The high range corresponds to systems where the water is conveyed in pipelines or over short distances so losses are small. This analysis assumes an average of 65-percent efficiency for overall conveyance efficiency.

Once water is conveyed to a field it must be applied, however, it is generally necessary to apply more water than the crop consumes to insure the crop gets enough water. The amount of water the crop needs is referred to as the consumptive use. The ratio of crop consumptive use to applied water is a measure of irrigation efficiency. Data on crop consumptive use was gathered from the United States Bureau of Reclamation AgriMet agricultural weather network and are given in Table 3.10 below. Blanks in Table 3.10 indicate the crop group is not widely grown in the region surrounding the specific weather station. Table 3.11 indicates which weather stations were used for which counties. Data on applied water by individual crop is not available. Instead, data on irrigation efficiency was used with the crop consumptive use data to calculate applied water. Irrigation efficiency data was available by crop in the 1998 Ranch and Farm Survey; however, it was only available at the state level rather than the county level. The state level weighted average irrigation efficiency for each crop group was found by multiplying the percentage for a given crop group under a given irrigation technology by the irrigation efficiency for that irrigation technology and summing across the different technologies. These are given in Table 3.12.

Applied water for each crop was found by dividing the consumptive water use by the irrigation efficiency, and is given in Table 3.13. Applied water use is a key component to identifying the amount of acreage that new water rights could support, and is discussed in the next section.

E. New Crop Acreage (step 4)

The process in determining new acreage is as follows: 1) the quantity of new water rights for a given county is determined; 2) this is multiplied by the average distribution efficiency; 3) the remaining water right is divided by the weighted average applied water for the county, which gives a total level of new acreage; and 4) the total new acreage is multiplied by the crop group proportions for the given scenario (see Table 3.14 as an example) to arrive at new acreage for each crop group for each county. Scenario 1 and upper bound Scenario 2 and 3 crop group proportions are based on the existing crop mix. Scenario 2 and 3 lower bound crop group proportions assume a slightly different crop mix with each scenario having progressively more high value crops and fewer low value crops. This accounts for changes in cropping patterns due to the increase in water use fees for those scenarios.

Scenarios 1, 2 and 3 all assume the same upper bound for new water rights and crop mix. New acreage for the upper bound is given in Table 3.15. The underlying assumption is the required BMP's and per acre-foot water charges in Scenarios 2 and 3 do not impact water demand significantly so the full 1 MAF are allocated for agricultural production. The common upper bound of water rights also implies the requirement that the majority of existing irrigators adopt BMP's is met. Meeting this requirement will increase instream flows if the adoption of BMP's reduces water losses like evaporation or excess applied water that does not become return flow to the hydrologic system. This analysis does not study the impact of adopting these BMP's, we only assume the majority adoption requirement is met.

No lower bound is placed on Scenario 1 since there are no BMP requirements on existing water users or additional water use fees. As such, it is possible that all water right would be used. However, it is also possible that not all 1 MAF of new water rights would be used. A lower bound can be estimated by finding a ratio of acres per acre-foot and scaling the amount of acreage appropriately.

The lower bound of new water rights for Scenario 2 is 700 KAF. The selection of this lower bound indicates that all water rights that are initially available are allocated, but the majority of existing water users do not adopt the new BMP's so the additional 300 KAF of water rights is not made available. The new acreage for the lower bound of Scenario 2 is given in Table 3.16. It is possible that less than the full 700 KAF would be requested if use of BMP's and the $10/AF charge act as a binding constraint on water use. The figures in Table 3.16 can be scaled down appropriately to find estimates of those possible cases. Note the crop mix in Table 3.16 is slightly different than that in Table 3.15. The Scenario 2 lower bound crop mix has a slightly higher percentage of orchard, vegetable, and potato crops to account for the likely change in crop mix as BMP's and the $10/AF charge comes into play.

The lower bound of new water rights for Scenario 3 is 568 KAF. This lower bound corresponds to the level of existing water right applications and an additional 220 KAF allocated to the Columbia Basin Project. This indicates that not all water rights that are initially available are allocated. That is, even though 700 KAF are made available, only the current applications are allocated because the BMP's and the $20/AF charge make use of the water rights too expensive for agricultural production. In addition, the majority of existing water users do not adopt the new BMP's so the additional 300 KAF of water rights is not made available either. The new acreage for the lower bound of Scenario 3 is given in Table 3.17. It is possible that less than the 568 KAF would be requested if use of BMP's and the $20/AF charge act as a strong constraint on water use. The figures in Table 3.17 can be scaled down appropriately to find estimates of those possible cases. Note the crop mix in Table 3.17 is slightly different than that in Tables 3.15 and 3.16. The Scenario 3 lower bound crop mix has a slightly higher percentage of orchard, vegetable, and potato crops to account for the likely change in crop mix for the higher cost of water.

F. Crop Value (step 5)

The per acre value of specific crop groups for this analysis is based on crop enterprise budgets developed at Washington State University. For budgets that did not list specific crop prices we used year 2000 price data from the WASS Annual Bulletin. The year 2000 was selected to correspond to the crop acreages discussed in section 3.B. Prices and non-water costs are assumed to be the same across all counties. Though this is a plausible assumption for price data, it is not likely to be the case for production costs. Unfortunately there is not enough data available to vary non-water production costs across counties. All costs and prices were brought forward to year 2003 values using a rate of 5-percent. Before we proceed to discussing the value of new water rights in irrigated agriculture we will give some background on the methodology and use of crop enterprise budgets.

The purpose of the budgets is to estimate the costs and returns from producing crops for research and policy purposes. They are also used to give producers and their credit providers a tool to use in enterprise selection and financing. To construct an enterprise budget, a group of producers is assembled by the extension agent in the area. The agent and a farm management specialist from WSU work with this group to develop a consensus estimate of enterprise costs and returns. It is fully realized by those involved in this process that the resulting enterprise budget does not represent any one particular farm; however, the resulting budget is a reasonable estimate for the area.

Producers reviewing these published budgets often state that their own costs are significantly lower than those presented in the WSU budgets. In fact, this is the case with most crop budgets that are developed nation wide. It is not uncommon for individuals to question the validity of the crop budgets since budgets may show producers are operating at a loss. To adequately address these concerns and questions, one must understand both the difference between “economic” and “cash” or “accounting” budgets and the concept of *opportunity cost*.

Opportunity cost is the revenue lost by not investing in the next best similar risk alternative. For instance, if a producer invests $50,000 of equity capital in machinery, the producer gives up the alternative of investing this money in the stock market or paying off a current loan. Thus, if the producer is to realize an *economic profit*, the machinery investment must realize a return greater than that associated with the next best alternative. If the next best alternative happens to be paying off a current loan with 10% annual interest, *economic profits* are not realized until a net return greater than $5,000 is realized by the equipment investment.

For land that is owned, the opportunity cost that is included in the WSU budget is the net rental return that the producer would receive if the land was rented out rather than being used by the producer. In short, it is assumed that the owner of capital assets and unpaid labor wants a “fair” market return for these resources. If full economic costs are not covered, a less than “fair” market return is being realized on these resources.

It is common for producers to own a large portion of their equipment. Cash or accounting budgets show the costs for the owned equipment to be zero, while an economic budget includes the opportunity cost of that equipment. As a result, an economic budget is likely to show lower profits than cash or accounting budgets. For example, the WSU budget for Native Spearmint produced using side roll irrigation to have a net economic return of negative $139. For this crop the fixed costs were $559 and the variable non-water costs were $1,157. If the grower owned half of the necessary equipment they would show a cash or accounting net return of over $140 per acre. Crop enterprise budgets assembled by WSU and other extension groups are economic budgets, not cash or accounting budgets. As such, they may show negative net economic returns when growers are actually making positive net cash or accounting returns.

The base per acre gross and net economic revenue figures calculated and used for Scenario 1 and the upper bounds for Scenarios 2 and 3 are given in Table 3.18. These per acre values do not vary by county. The per acre net economic revenue figures for the lower bounds on Scenario's 2 and 3 do vary by county due to the variation in consumptive water use and per acre charges for water. The gross revenue figures for the crop groups compare favorably to existing studies shown from the Washington Agricultural Statistics Service. Most studies to not estimate the net revenue of crop production so it is difficult to make any comparisons with these.

Table 3.1: Scenario 1, Gross Revenue of Irrigated Acreage (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	3,422	175,425	38,629	15,756	24,578	1,699	259,509
Chelan	106	32,082	0	0	0	0	32,188
Douglas	497	61,790	0	0	0	210	62,497
Ferry	0	0	0	0	0	0	0
Franklin	789	1,956	1,177	409	891	240	5,462
Grant	6,517	27,915	10,895	8,540	4,821	2,855	61,544
Kittitas	0	0	0	0	0	0	0
Klickitat	735	3,879	0	782	543	223	6,161
Lincoln	0	0	0	0	0	0	0
Okanogan	2,397	52,346	0	104	0	35	54,882
Stevens	107	36	0	48	0	19	209
Walla Walla	133	1,396	964	384	338	290	3,505
Crop Total	14,702	356,825	51,666	26,022	31,172	5,571	485,957

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 919,248 af are allocated to irrigated agriculture in this scenario.

Table 3.2: Lower Bound Scenario 2, Gross Revenue for 700 kAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	2,432	124,664	27,451	11,197	17,466	1,208	184,418
Chelan	79	23,859	0	0	0	0	23,938
Douglas	369	45,952	0	0	0	156	46,478
Ferry	0	0	0	0	0	0	0
Franklin	544	1,349	812	282	614	165	3,767
Grant	3,498	14,985	5,849	4,584	2,588	1,532	33,037
Kittitas	0	0	0	0	0	0	0
Klickitat	546	2,884	0	582	404	166	4,582
Lincoln	0	0	0	0	0	0	0
Okanogan	1,782	38,929	0	77	0	26	40,815
Stevens	80	26	0	36	0	14	156
Walla Walla	80	842	582	231	204	175	2,114
Crop Total	9,411	253,491	34,693	16,989	21,277	3,442	339,302

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 619,248 af are allocated to irrigated agriculture in this scenario.

Table 3.3: Lower Bound Scenario 3, Gross Revenue for 568 kAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	1,284	65,836	14,497	5,913	9,224	638	97,392
Chelan	47	14,329	0	0	0	0	14,376
Douglas	222	27,597	0	0	0	94	27,913
Ferry	0	0	0	0	0	0	0
Franklin	260	646	389	135	294	79	1,802
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	328	1,732	0	349	243	99	2,751
Lincoln	0	0	0	0	0	0	0
Okanogan	1,070	23,379	0	46	0	16	24,512
Stevens	48	16	0	21	0	8	93
Walla Walla	19	200	138	55	48	42	501
Crop Total	3,279	133,734	15,024	6,520	9,809	976	169,341

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 491,570 af are allocated to irrigated agriculture in this scenario.

Table 3.4: Scenario 1, Net Revenue of Irrigated Acreage (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	160	27,080	3,262	-1,308	1,294	-532	29,955
Chelan	5	4,952	0	0	0	0	4,957
Douglas	23	9,538	0	0	0	-66	9,496
Ferry	0	0	0	0	0	0	0
Franklin	37	302	99	-34	47	-75	376
Grant	304	4,309	920	-709	254	-894	4,184
Kittitas	0	0	0	0	0	0	0
Klickitat	34	599	0	-65	29	-70	527
Lincoln	0	0	0	0	0	0	0
Okanogan	112	8,080	0	-9	0	-11	8,172
Stevens	5	5	0	-4	0	-6	1
Walla Walla	6	216	81	-32	18	-91	198
Crop Total	685	55,082	4,363	-2,160	1,641	-1,745	57,867

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 919,248 af are allocated to irrigated agriculture in this scenario.

Table 3.5: Scenario 2: Net Revenue of Irrigated Acreage Using 700 kAF (in Thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	-116	18,500	1,940	-1,285	468	-457	19,052
Chelan	-2	3,556	0	0	0	0	3,554
Douglas	-11	6,849	0	0	0	-49	6,790
Ferry	0	0	0	0	0	0	0
Franklin	-26	200	57	-32	16	-62	153
Grant	-133	2,214	429	-527	70	-576	1,478
Kittitas	0	0	0	0	0	0	0
Klickitat	-21	428	0	-67	11	-63	288
Lincoln	0	0	0	0	0	0	0
Okanogan	-54	5,791	0	-6	0	-10	5,721
Stevens	-2	4	0	-3	0	-5	-7
Walla Walla	-4	125	41	-27	5	-66	75
Crop Total	-368	37,668	2,468	-1,947	572	-1,287	37,106

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 619,248 af are allocated to irrigated agriculture in this scenario.

Table 3.6: Scenario 3, Net Revenue of Irrigated Acreage Using 568 kAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	0	0	0	0	0	0	0
Benton	-182	9,378	825	-866	9	-283	8,881
Chelan	-5	2,060	0	0	0	0	2,055
Douglas	-23	3,967	0	0	0	-29	3,915
Ferry	0	0	0	0	0	0	0
Franklin	-37	92	22	-20	0	-35	23
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	-41	247	0	-52	0	-44	111
Lincoln	0	0	0	0	0	0	0
Okanogan	-114	3,347	0	-4	0	-7	3,222
Stevens	-5	2	0	-2	0	-4	-8
Walla Walla	-3	28	8	-8	0	-18	7
Crop Total	-410	19,120	855	-951	10	-420	18,205

Source: calculated using value, acreage, water use and irrigation technology data discussed in the CRI report. Note that only 491,570 af are allocated to irrigated agriculture in this scenario.

Table 3.7: Irrigated Acres for Counties using Columbia River Water

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
Adams	23684	3328	3668	36483	27914	47137	142214
Benton	14188	38153	22967	37306	24259	9792	146665
Chelan	1101	28603	12	0	0	0	29716
Douglas	1649	17355	1170	0	0	796	20970
Ferry	4648	0	0	0	0	0	4648
Franklin	75339	14308	28308	22305	35770	37798	213828
Grant	120696	40623	55754	90333	43023	83042	433471
Kittitas	42592	2236	4437	633	442	4536	54876
Klickitat	7276	2265	0	4424	0	2040	16005
Lincoln	7857	85	0	6749	771	30539	46001
Okanagon	15300	28319	22	378	0	260	44279
Stevens	5941	167	20	1515	0	1192	8835
Walla Walla	14439	8003	13520	23828	9255	23752	92797
Total	334710	183445	129878	223954	141434	240884	1254305

Source: 1997 Census of Agriculture. These are approximate because a few of the numbers came out slightly negative because of the way the Census reports Irrigated Acres. Those numbers were set to zero.

Table 3.8: Summary of Approximate Irrigated Acres for Counties Relevant to the Columbia River

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
Adams	15459	3854	8987	23814	26000	64100	142214
Benton	10187	44189	27705	26785	32000	5800	146665
Chelan	1113	28603	0	0	0	0	29716
Douglas	1649	17355	0	0	0	800	19804
Ferry	4648	0	0	0	0	0	4648
Franklin	78978	16572	28396	23382	39000	27500	213828
Grant	129795	47050	52284	97143	42000	65200	433471
Kittitas	40214	2590	6339	598	600	4536	54876
Klickitat	5872	2623	0	3570	1900	2040	16005
Lincoln	5972	98	0	5130	6000	28800	46001
Okanagon	15321	28319	0	379	0	260	44279
Stevens	5957	167	0	1519	0	1192	8835
Walla Walla	10414	9269	18229	17185	11600	26100	92797
Total	325578	200689	141939	199504	159100	226328	1253139

Source: 1997 Census of Agriculture and various WASS studies

Table 3.9: Summary of Water Use by County

County	Columbia River Water Rights (acre-feet)[1]	Ratio of Columbia River Water Rights to Irrigated Acreage[2]	Alternative Water Sources[3]
Adams	CBP rights	--	Groundwater
Benton	922,104	5.6	Yakima River
Chelan	138,018	2.9	Wenatchee River and Lake Chelan
Douglas	194,764	4.2	Groundwater
Ferry	11,742	2.4	Kettle and Sanpoil Rivers
Franklin	83,285	0.3	Snake River
Grant	3,329,854	7.2	Groundwater
Kittitas	11,703	0.0	Yakima River
Klickitat	43,203	1.6	Groundwater
Lincoln	11,521	0.1	Spokane River
Okanogan	98,005	1.4	Okanogan River
Stevens	19,264	1.3	Spokane River
Walla Walla	170,789	1.3	Snake River
Yakima	3	0	Yakima River

[1] DOE Columbia River water rights spreadsheet.
[2] This is total Columbia River water rights divided by irrigated acreage from the 1997 census given in Table 3.7.

[3] These indicate irrigation water source alternatives to the Columbia River.

Table 3.10: Consumptive Water Use by Crop and County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Weighted Average
Adams	2.74	2.82	1.38	1.69	2.06	1.86	1.96
Benton	3.02	2.54	1.96	1.96	2.08	1.93	2.23
Chelan	2.41	2.26	--	--	--	--	2.27
Douglas	2.41	2.26	--	--	--	--	2.18
Ferry	2.46	2.39	--	--	--	1.67	2.46
Franklin	3.02	2.54	1.96	1.96	2.08	1.93	2.41
Grant	2.71	2.82	1.57	1.98	2.04	1.86	2.23
Kittitas	2.71	2.82	1.57	1.98	2.04	1.86	2.50
Klickitat	2.73	2.51	1.76	2.00	2.08	1.92	2.35
Lincoln	2.78	--	1.82	2.15	2.09	1.93	2.08
Okanogan	2.46	2.39	--	--	--	1.67	2.39
Stevens	2.46	2.39	--	--	--	1.67	1.93
Walla Walla	3.02	2.54	1.96	1.96	2.08	1.93	2.14
Average	2.69	2.52	1.75	1.96	2.07	1.84	2.24

Source: historical water use based on AgriMet weather station. Blanks indicate the crop group is not widely grown in the region surrounding the specific weather station http://www.usbr.gov/pn/agrimet/ETtotals.html. Weighted average is based on base acreage

Table 3.11: AgiMet Weather Stations for Water Use

County	Weather Station
Adams	LIDW -- Lind, Washington and GERW -- George, Washington
Benton	LEGW -- Legrow, Washington
Chelan	MASW -- Manson, Washington
Douglas	MASW -- Manson, Washington
Ferry	OMAW -- Omak, Washington
Franklin	LEGW -- Legrow, Washington
Grant	GERW -- George, Washington
Kittitas	GERW -- George, Washington
Klickitat	HRHW -- Harrah, Washington
Lincoln	ODSW -- Odessa, Washington
Okanogan	OMAW -- Omak, Washington
Stevens	OMAW -- Omak, Washington
Walla Walla	LEGW -- Legrow, Washington

Table 3.12: Percentage of Irrigation Technology by Crop

Technology	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Technology Efficiency
Sprinkler	0.59	0.66	0.83	0.68	0.89	0.88	0.70
Gravity	0.33	0.07	0.10	0.10	0.02	0.09	0.50
Other	0.08	0.27	0.07	0.22	0.09	0.04	0.85
Weighted Average Efficiency	0.65	0.73	0.69	0.71	0.71	0.69	

Source: percentage by crop are from http://www.nass.usda.gov/census/census97/fris/tbl23.pdf and http://www.nass.usda.gov/census/census97/fris/tbl4.pdf. Irrigation efficiencies are based on http://farm-mgmt.wsu.edu/PDF-docs/misc/eb1875.pdf

Table 3.13: Applied Water by Crop and County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Weighted Average
Adams	4.23	3.87	2.00	2.37	2.90	2.71	2.84
Benton	4.67	3.49	2.83	2.76	2.92	2.81	3.16
Chelan	3.73	3.11	--	--	--	--	3.13
Douglas	3.73	3.11	--	--	--	--	3.04
Ferry	3.80	3.29	--	--	--	2.42	3.80
Franklin	4.67	3.49	2.83	2.76	2.92	2.81	3.57
Grant	4.19	3.87	2.27	2.78	2.88	2.70	3.26
Kittitas	4.19	3.87	2.27	2.78	2.88	2.70	3.80
Klickitat	4.22	3.45	2.54	2.81	2.94	2.79	3.45
Lincoln	4.29	--	2.63	3.02	2.95	2.80	3.03
Okanogan	3.80	3.29	--	--	--	2.42	3.43
Stevens	3.80	3.29	--	--	--	2.42	2.95
Walla Walla	4.67	3.49	2.83	2.76	2.92	2.81	3.10
Weighted Average	4.24	3.47	2.55	2.70	2.91	2.72	3.24

Source: Figures in Table 3.10 divided by figures in Table 3.12.

Table 3.14: Scenario 1: Portion of Crop by County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
Adams	0.11	0.03	0.06	0.17	0.18	0.45
Benton	0.07	0.30	0.19	0.18	0.22	0.04
Chelan	0.04	0.96	0.00	0.00	0.00	0.00
Douglas	0.08	0.88	0.00	0.00	0.00	0.04
Ferry	1.00	0.00	0.00	0.00	0.00	0.00
Franklin	0.37	0.08	0.13	0.11	0.18	0.13
Grant	0.30	0.11	0.12	0.22	0.10	0.15
Kittitas	0.73	0.05	0.12	0.01	0.01	0.08
Klickitat	0.37	0.16	0.00	0.22	0.12	0.13
Lincoln	0.13	0.00	0.00	0.11	0.13	0.63
Okanogan	0.35	0.64	0.00	0.01	0.00	0.01
Stevens	0.67	0.02	0.00	0.17	0.00	0.13
Walla Walla	0.11	0.10	0.20	0.19	0.13	0.28
Portion of Total	0.26	0.16	0.11	0.16	0.13	0.18

Source: 1997 Census of Agriculture and Washington Agricultural Statistical Service.

Table 3.15: New Crop Acreage for Scenario 1 and Upper Bound for Scenarios 2 and 3; 1 MAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total New Acres
Adams	0	0	0	0	0	0	0
Benton	6,905	29,954	18,780	18,157	21,692	3,932	99,420
Chelan	213	5,478	0	0	0	0	5,691
Douglas	1,002	10,551	0	0	0	486	12,040
Ferry	0	0	0	0	0	0	0
Franklin	1,592	334	572	471	786	554	4,311
Grant	13,150	4,767	5,297	9,842	4,255	6,605	43,915
Kittitas	0	0	0	0	0	0	0
Klickitat	1,482	662	0	901	480	515	4,041
Lincoln	0	0	0	0	0	0	0
Okanogan	4,836	8,938	0	119	0	82	13,976
Stevens	216	6	0	55	0	43	321
Walla Walla	268	238	469	442	298	671	2,387
Total	29,665	60,929	25,118	29,988	27,511	12,889	186,100

Note that only 919,248 acre-feet are allocated to irrigated agriculture in this scenario. The remaining water is allocated to municipal and industrial users.

Table 3.16: New Crop Acreage for the Lower Bound of Scenario 2; 700 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total New Acres
Adams	0	0	0	0	0	0	0
Benton	4,907	21,287	13,346	12,903	15,415	2,794	70,652
Chelan	159	4,074	0	0	0	0	4,233
Douglas	746	7,846	0	0	0	362	8,954
Ferry	0	0	0	0	0	0	0
Franklin	1,098	230	395	325	542	382	2,973
Grant	7,059	2,559	2,843	5,283	2,284	3,546	23,574
Kittitas	0	0	0	0	0	0	0
Klickitat	1,102	492	0	670	357	383	3,005
Lincoln	0	0	0	0	0	0	0
Okanogan	3,596	6,647	0	89	0	61	10,393
Stevens	161	5	0	41	0	32	239
Walla Walla	162	144	283	267	180	405	1,439
Total	18,989	43,284	16,867	19,578	18,778	7,965	125,461

Note that only 619,248 acre-feet are allocated to irrigated agriculture in this scenario. The remaining water is allocated to municipal and industrial users.

Table 3.17: New Crop Acreage for the Lower Bound of Scenario 3; 568 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total New Acres
Adams	0	0	0	0	0	0	0
Benton	2,592	11,242	7,048	6,814	8,141	1,476	37,312
Chelan	95	2,447	0	0	0	0	2,542
Douglas	448	4,712	0	0	0	217	5,377
Ferry	0	0	0	0	0	0	0
Franklin	525	110	189	156	259	183	1,422
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	662	296	0	402	214	230	1,804
Lincoln	0	0	0	0	0	0	0
Okanogan	2,160	3,992	0	53	0	37	6,242
Stevens	97	3	0	25	0	19	143
Walla Walla	38	34	67	63	43	96	341
Total	6,616	22,835	7,304	7,513	8,657	2,258	55,184

Note that only 491,570 acre-feet are allocated to irrigated agriculture in this scenario. The remaining water is allocated to municipal and industrial users.

Table 3.18: Gross and Net Economic Returns for Scenario 1 and Upper Bound for Scenarios 2 and 3

	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
Gross Revenue	496	5,856	2,057	868	1,133	432
Net Economic Returns	23	904	174	-72	60	-135

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CHAPTER 4. ECONOMIC VALUE OF NEW MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

A. Overview of M&I Water Use

Diversions of Columbia River water to cities and industries occurs, but these diversions are small relative to irrigation and have little measurable impact on the operation of the river system. The level of M&I depletion is so small that some researchers have ignored it as a consumptive use of water altogether. The Columbia River SOR (1995) considered depletions to be insignificant in the measurement of impacts under alternative operating strategies. They cite that public water supply and domestic use account for 4% of diversions, commercial use about 2%, and industrial use about 2%. Furthermore, water withdrawn for non-agricultural use has a higher return flow than for agricultural uses, and accordingly, depletion for M&I uses was estimated at less than 2%. The BPA (1993) concludes similarly. They assert that the magnitude of M&I consumptive use in the Pacific Northwest is minor when compared to the consumptive use of agriculture. In addition, large streamflows in comparison to M&I diversions results in the BPA's conclusion that the estimate of M&I depletion is inconsequential and not required in deriving modified streamflows. They show that 97.3% of consumptive use is due to agricultural diversions.

However, despite the conclusion that diversions of M&I water results in very small changes of in-stream flows, the value of water to M&I users may be higher than the value of water to irrigators and other users of water. The fact that water is necessary for sustaining human life implies that M&I users will have a very high marginal value for water in years when water is in short supply. Conversely, in years when there is ample water, the marginal value of water to M&I users will be much lower.

To summarize M&I use for rights within one mile of the Columbia River, about 93 KAF of water, or about 2.0%, is used for municipal uses; while about 244 KAF, or about 5.3% is used for industrial use[5]. When considering applications for water, the relative amount of water used for M&I purposes increases. Of the applications for M&I water within one mile of the Columbia, about 69 KAF, or 11.4%, is for municipal uses; while about 7.5 KAF, or 1.2%, is for industrial

[5] Ecology specifies uses as Domestic/General & Municipal and Commercial & Industrial. The first category is essentially "Municipal" and the second category is essentially "Industrial."

uses. The relatively large application pool for municipal water might reflect the increasing demands for water in rapidly developing areas. As discussed in Chapter 2, nearly all of the M&I applications that exist are for counties near the Tri-Cities area. The table below summarizes rights and applications for M&I water by county.

Table 4.1 Existing M&I Rights and Applications

County	Certificates & Permits (AF)	Applications (AF)
Benton	223,081	65,085
Chelan	33,878	0
Douglas	101	0
Ferry	4	0
Franklin	7,774	5,203
Grant	2,539	0
Kittitas	62	0
Klickitat	25,416	5
Lincoln	676	0
Okanogan	2,467	0
Stevens	2,737	0
Walla Walla	38,303	6,504
Total	337,039	76,798

B. M&I Water Values

Finding good sources for ways to value water used for municipal and industrial (M&I) purposes has been a problem for the study team. The study team would like to explore the value of M&I water using purchases of water for M&I use and/or the cost of reclaiming and treating water for M&I use.

We would like to value M&I use at a market price, but there seem to be few reliable examples of water purchases in Washington. The publication “The Water Strategist” has some records of water purchases for different purposes. In all, there are only 4 transactions for M&I water in Washington since January of 2000. For example, two purchases in Washington were for M&I uses during 2001. The City of Warden purchased 2,388 AF of Grande Ronde Aquifer GW from an irrigator at a price of $452/AF in June. Also, various businesses, farms, and the Church of Latter Day Saints leased up to 2,596.5 AF of Columbia Basin Project water from the Bureau of Reclamation for $39/AF with a minimum lease of $500 in July and August of 2001. There seems to be a large discrepancy in prices for these two purchases. Nonetheless, water purchases for M&I uses seem to be an appropriate way to show a lower bound for the value of M&I water.

Another way to value M&I water is through the cost of re-claiming and treating wastewater. There are a number of on-line sources we have referenced, including the EPA's Wastewater Management website, the National Onsite Wastewater Recycling Association's (NOWRA) website, and Water and Wastewater.com, however none of them have reports addressing the value of reused water in terms of the cost of retreating in Washington.

Other informational sources include the John Day Drawdown report from the Corps which includes both a profile of M&I users to the John Day pool, and costs to modifying M&I water supply systems under a few scenarios. The study focuses on M&I users adjacent to the John Day pool, with a heavier emphasis on those users in the state of Oregon. The Washington users include Columbia/Goldendale Aluminum, Patterson, and other publicly and privately owned wells. The report distinguishes between SW users and GW users, of which Columbia/Goldendale Aluminum is the only SW user in Washington. The report summarizes construction and annual costs of M&I water supply facility modifications if the John Day pool was to be drawn down to its natural level, and to the spillway crest.

Other Sources/References??

C. Impact of the Scenarios on M&I Water

The issuance of water rights for M&I purposes seems to be a higher priority than that of irrigation purposes because of M&I's relatively large marginal value when compared to irrigation. It seems reasonable to conclude that water applications for M&I use will be granted by Ecology as long as the municipalities requesting the water can provide evidence that there is an increasing need for M&I water due to urban expansion or population increases.

For the scenarios considered in this report, it has been shown that the most important urban area with respect to the Columbia River is the Tri-Cities. We have assumed that the Tri-Cities population trend shows roughly a 30% increase in the next 10 to 20 years, and correspondingly, a 30% increase in the need for water. Furthermore, we have assumed that in each scenario, and at the low-level assessment and high-level assessment (applicable to scenarios 2 and 3), M&I water will be granted rights ahead of irrigation water. In each case, the 30% increase in the water needs of the Tri-Cities has been a high priority. Furthermore, in a situation such as scenario 4, where new rights are only permitted through transfers and conservation measures, it seems likely that municipalities would acquire water through leasing from irrigators when necessary. This is similar to when Ecology leased water from an irrigator for the City of Richland in 2001. (*Is there records of this transaction for a reference?*)

In each of the scenarios, M&I water will be granted its needs because it is a high valued water use. Therefore, although M&I impacts exist, they will not vary across scenarios, and for that reason will be unchanged when comparing scenarios. The impacts on M&I water will be the same for each scenario.

CHAPTER 5. ECONOMIC EFFECTS ON HYDROPOWER GENERATION

The withdrawal of additional water for out-of-stream use will reduce the flow of water downstream from the diversion point, and this will reduce the potential production of hydroelectric power at all dams downstream of the diversion. For each pool in the mainstem river from Grand Coulee to John Day we calculate a power loss in the following steps:

- calculate the change in flow caused by the new diversion amounts, diversion timing, and the expected return flows for each month of the year;
- multiply the flow change by the monthly “power factors” for each downstream hydropower dam (i.e. megawatts produced per thousand cubic feet per second (kcfs)), times hours for each month;
- multiply resulting hydropower reduction by prices forecasted for each month;

This computation is performed for an average water year (averaged over 1929 – 1978) and for a very dry year (1977). In the current version of this analysis, the power factors vary between average and dry years but the power price forecasts do not. The price forecasts used here were developed at the Bonneville Power Administration based upon assumptions about future load, generation resources, natural gas prices, and precipitation patterns in the Columbia basin for each month (from A. Perino).

The results for Management Scenario 1, which adds 1 million acre-feet of new diversions -- 919,248 acre-feet of which is for irrigated agriculture -- are displayed in Table 5.1 We have assumed here that essentially all of the water diverted for municipal and industrial use returns to the river near the point of diversion. The full cost to the hydroelectric power system of new withdrawals (distributed across reservoirs as shown estimated in Table 1.4) varies from $9.4 million/year in average water years to $9.7 million/yr in a dry year. These estimates of value are sensitive to the assumptions about prices, which have been volatile in recent years. Table 5.1 is based upon an average price forecast for 2003 – 2012. These forecasts include both “high load hour” (HLH) and “low load hour” (LLH) forecasts, where the high load hours are basically between 7 am and 9 pm. In addition, we have the “flat prices” which are a weighted average of HLH and LLH prices. Table 5.1 is based upon the HLH prices, because we assume that any marginal increase in water available for hydropower generation would be used during the high demand hours. We do not have separate price forecasts for “dry years” and average water years.

If hydropower is significantly scarce in dry years, the price could be substantially higher that the forecast prices. In addition to the loss of hydropower generation, there would be an increase power consumption, worth an estimated $2.465 million per year, associated with pumping the additional 220 kaf of water from Grand Coulee reservoir to Banks Lake for the Columbia Basin Project.

Hydropower costs associated with Management Scenarios 2 and 3 can be estimated in a manner similar to the costs listed in Table 5.1, simply by modifying the assumptions regarding magnitude and timing of new diversions. For example, under Scenario 2 only 700 kaf of new water rights would be allocated initially, with 300 kaf being contingent upon whether 80% of water use conforms to efficiency Best Management Practices (BMPs). If water users meet the standards initially and the full 1 MAF in new water rights are permitted, the hydropower loss under Scenario 2 is the same as under Scenario 1. Alternatively, if either (a) the majority of water users do not meet water efficiency BMPs or (b) the costs of meeting BMPs and paying the proposed fee of $10/acre-foot per month is too high to attract the full 1 MAF of new water rights, then the hydropower cost of Scenarios 2 would be lower. For example, if only the first 700 kaf of new water rights are allocated, and all the M&I water demand is included in this, then the new agricultural diversions will amount to 619,247 acre-feet. Then we allocate this over reservoirs by assigning the full 220 kaf proposed to the Columbia Basin Project (Grand Coulee) and assign the remaining water among reservoirs in proportion to the amounts in the application pool. The resulting hydropower costs range from $7.87 million in an average water year to $8.11 million in a dry year when valued at the HLH prices (Table 5.2). Valued at LLH prices these costs drop to between $6.0 million and $6.16 million. We have no basis presently to estimate when the BMP standards would be met by 80% of water users.

Scenario 3 would have costs very similar to Scenario 2, except that the fees charged for new water rights rise to $20/acre-foot. Again, if all 1 MAF of the proposed new water rights are taken, despite the higher fees, the hydropower impact would be the same as with Scenario 1. On the other hand, the higher fees may discourage some prospective water uses. To provide a range of possible impacts, we consider a lower-bound estimate of new water rights allocation of 568 kaf, which equals the existing application pool, minus the application for hydropower use at the Dalles (Klickitat Co PUD), plus the proposed allocation of 220 kaf to the Columbia Basin Project. This lower bound is chosen to be below the 700 kaf lower bound adopted for Scenario 2, because the higher fee is bound to discourage more low-valued water applications. The hydropower losses associated with this lower bound estimate are displayed in Table 5.3, and amount to between $7.18 million and $7.41 million per year. Also, the State may develop additional storage, which could change the timing and quantity of flows available to hydropower at some dams.

Scenario 4 would cause little or no loss of hydropower production, because all new water rights would be offset through transfers, conservation, and/or new storage. And, finally, Scenario 5 would cause no loss of hydropower from the status quo, base condition.

Details of these hydropower value calculations are described in the following sections.

Table 5.1 Summary of Estimated Power Losses Associated with Scenario 1 New Water Rights, valued at "High Load Hour" (HLH) price forecasts averaged for 2003-2012.

Dam	New Diversion	MWh Loss		Cost per Acre-foot		Lost Hydropower	
	Acre-Feet	Ave Year	Dry Year	Ave Year	Dry Year	Ave Year	Dry Year
Grand Coulee	221,456	178,720	185,953	$26.23	$27.21	$5,809,848	$6,025,598
Chief Joseph	1,660	740	771	$13.35	$13.88	$22,157	$23,047
Wells	120,591	38,568	40,199	$9.57	$9.98	$1,154,535	$1,203,198
Rocky Reach	17,264	4,779	4,935	$8.28	$8.56	$143,025	$147,765
Rock Island	13,768	2,998	3,086	$6.52	$6.71	$89,721	$92,438
Wanapum	4,136	809	833	$5.85	$6.04	$24,195	$24,973
McNary	237,964	34,046	33,298	$4.50	$4.40	$1,071,797	$1,047,908
John Day	302,409	35,562	35,868	$3.72	$3.75	$1,124,516	$1,134,969
Total	919,248	296,223	304,943	$10.27	$10.55	$9,439,795	$9,699,897

Table 5.2 Hydropower Losses with 700 kaf of new diversions and HLH Prices

Dam	New Diversions Acre-Feet	MWh Loss		Cost per Acre-foot		Value of Power Loss	
		Ave Year	Dry Year	Ave Year	Dry Year	Ave Year	Dry Year
Grand Coulee	221,177	178,495	185,719	$26.23	$27.21	$5,802,527	$6,018,006
Chief Joseph	947	422	440	$13.35	$13.88	$12,640	$13,148
Wells	68,794	22,002	22,932	$9.57	$9.98	$658,631	$686,392
Rocky Reach	9,848	2,726	2,815	$8.28	$8.56	$81,592	$84,296
Rock Island	7,854	1,711	1,760	$6.52	$6.71	$51,183	$52,733
Wanapum	2,359	461	475	$5.85	$6.04	$13,803	$14,247
McNary	135,752	19,422	18,996	$4.50	$4.40	$611,431	$597,803
John Day	172,516	20,287	20,462	$3.72	$3.75	$641,506	$647,469
Total	619,248	245,527	253,599	$12.71	$13.10	$7,873,313	$8,114,093

Table 5.3 Hydropower Losses with 568 kaf (491.57 for agriculture) of new diversions at HLH Prices

Dam	New Diversions Acre-Feet	MWh Loss		Cost per Acre-foot		Value of Power Loss	
		Ave Year	Dry Year	Ave Year	Dry Year	Ave Year	Dry Year
Grand Coulee	221,054	178,396	185,616	$26.23	$27.21	$5,799,302	$6,014,661
Chief Joseph	633	282	294	$13.35	$13.88	$8,452	$8,792
Wells	46,003	14,713	15,335	$9.57	$9.98	$440,433	$458,997
Rocky Reach	6,586	1,823	1,882	$8.28	$8.56	$54,561	$56,370
Rock Island	5,252	1,144	1,177	$6.52	$6.71	$34,227	$35,263
Wanapum	1,578	309	318	$5.85	$6.04	$9,230	$9,527
McNary	90,778	12,988	12,703	$4.50	$4.40	$408,870	$399,757
John Day	115,363	13,566	13,683	$3.72	$3.75	$428,981	$432,969
Total	487,248	223,221	231,008	$14.74	$15.22	$7,184,057	$7,416,335

A. Detailed Description of Power Loss Calculation Method

We adopt an approach similar to that used by John Fazio of the Northwest Power and Conservation Council (memo of May 9, 2000) to estimate hydropower system losses due to additional diversions. We calculate flows and generation losses at each affected dam. For each diversion, we identify the pool from which the water is drawn (call it dam i). So, the annual increased diversion in acre-feet at dam i is indicated by the variable, ΔD_i. These values are listed in Table 1.5 above. Then we perform the following 5 steps.

1. Estimate the increased diversion in acre-feet (af) by month of the year based upon estimated seasonal distribution of diversions for the type considered. With M_{ij} representing the % of the water right that would be diverted at dam i in month j, we multiply to get the monthly diversion volume at dam i in month j, $\Delta D_i x M_{ij}$.

2. Convert the volume of water diverted in acre-feet into flow. A flow of 1 cfs for a day is equivalent to 1.98 acre-feet. So, the average in-stream flow reduction in cfs due to a diversion of ΔDM_{ij} for a month would be equal to $\Delta D_i x M_{ij} /(1.98DAY_j)$, where DAY_j is the number of days in month j.

3. Calculate the hydropower generation lost at dam i in each month j by multiplying the change in flow by the "power factor" HK_{ij}, which is the megawatt production (MW) produced under stipulated system operating rules at the dam per thousand cfs (Kcfs) of flow. The we divide by 1000 to convert to Kcfs and mulitply by 720, the number of hours in a month, to get megawatt hours of energy. In symbols, the hydropower generation loss at dam i in month j would be:

(1) $$\Delta MW_{ij} = 0.72*HK_{ij} *\Delta D_i x M_{ij} /(1.98DAY_j).$$

Because the water diverted at one dam and consumed by the water user is unavailable at all subsequent dams downstream, we add up the power factors for all dams downstream of the diversion point (call this HKSUM) and substitute this for HK in equation (1) to get total system power loss:

(2) $$\Delta MW^*_{ij} = 0.72 * HKSUM_{ij} * \Delta D_i x M_{ij} /(1.98DAY_j).$$

4. Because a significant amount of water returns to the river at or below the diversion point, we need to adjust the calculated power loss to account for power produced at downstream dams by return flow. Letting RFM_{ijk} be the percent of water diverted at point i that returns in month j at

site k, we can calculate the power generation due to return flow from diversion at dam i in month j as:

(3) $RMW_{ij} = 0.72 * \Sigma [\Delta D_i * RFM_{ijk} /(1.98 DAY_j)] \text{ x } HKSUM^*_{ij}$

where the summation is over i, downstream dam sites.

5. The value of the power loss due to diversion at dam i in month j is calculated by multiplying the change in power generation by a forecasted monthly price. These forecasts can be obtained from the Bonneville Power Administration or from technical staff at the Northwest Power and Conservation Council. The prices for mid-Columbia wholesale transactions vary across months; they vary from peak to non-peak hours; and they are expected to vary across water years. In dry years, the prices would typically be somewhat higher than in wet years. We currently do not have forecasted dry year prices. Potential power value loss is calculated as:

(4) $\Delta PV_{ij} = P_{ij} \text{ x } (\Delta MW^*_{ij} - RMW_{ij}) = P_{ij} \text{ x } [\Delta MW^*_{ij} - \Sigma\, RFM_{ijk} \text{ x } \Delta MW^*_{ij}]$.

B. Hydropower Loss for Diversion at the Columbia Basin Project

The diversion of an additional 221,456 AF at Lake Roosevelt for irrigation (Table 2.6) would occur over the months of the growing season, and return flows from those diversions to lower pools would be spread over the year as indicated in Table 5.4, which shows the estimated percentage distribution of diversions and return flows over months. These monthly diversion and return flow patterns are taken from Bonneville Power Administration (1993a). Overall, about 23.7% of the water diverted eventually returns to reservoirs downstream. Assuming the new diversion of 221,456 acre-feet from Lake Roosevelt and associated return flows follows that established pattern, we expect the flows (in cfs) to be distributed across months as shown in Table 5.2. These are calculated in accordance with the term $\Delta D_i x M_{ij} /(1.98 DAY_j)$ as explained above. We assign numbers to projects starting with Grand Coulee as 1, and proceeding downstream. So, for example, Wanapum dam is site 6. The monthly flow changes are in Table 5.5. We use the system power factors (H/Ks) in Table 5.6a (or Table 5.6b for a dry year) to calculate the change in monthly hydropower production at each dam, based on equations (2), (3) and (4) above. Then we multiply each estimated Mwh change by a monthly-varying price as displayed in Table 5.7. These prices are forecasts by the Bonneville Power Administration for the years 2010-2025, which covers a period in the midst of the CRI water allocation period.

So, for the additional 221,456 acre-foot diversion at Grand Coulee in an average water year we get a net loss of generation at Grand Coulee and downstream dams of 198,205 MWh, which is worth $6,261,439 at the High Load Hours price in Table 5.7. Return flows at Wanapum, Priest Rapids and McNary dams will generate a total of 12,251 Mwh, worth $615, 324 per year at the flat rate mid-C prices. The net loss of hydropower generation value is $5,809,848, or $26.23 per acre-foot of new diversion. In a very dry year (1976-77) the power factors are slightly higher (HKSUMs) due to changes in the operation of the system to utilized a higher percentage of the water. A re-computation of hydropower losses and wholesale market value of the losses for a dry year yields a net loss of hydropower value due to new diversions from Grand Coulee reservoir to the Columbia Basin Project of $6,025,598 (or $27.21 per acre-foot of water diverted). The results are sensitive to the price assumptions. For example, for an average water year and Low Load Hour prices we get a net loss of hydropower generation worth $5,209,660 million ($23.52 per acre-foot). Generally, we would expect the extra hydropower to be generated during High Load Hours, because hydropower plants are very good at following load, while thermal plants are generally used for base load. Hence, the High Load Hour price is more likely to represent the value of lost hydropower.

An additional issue is the power consumed in pumping the new water allocation for 220 kaf for the Columbia Basin Project. This water would be pumped from the reservoir to Banks Lake for distribution down canals to irrigation districts in the project area. According to estimates by John Fazio, the power demands (in Mwh) per thousand acre-feet are as listed in Table 5.4. Multiplying these power demands times the diversions per month (first column of Table 5.5) times the Mid-C average prices (for Low-Load Hours) yields a hydroelectric cost of $2,465,542. That cost could be added on to the value of lost hydropower production in calculating the overall hydropower cost of the new diversion. The total for the 1 maf diversion would then be $12,165,450 per year.

Table 5.4 Seasonal distribution of diversions for the Columbia Basin Project, and return flows to downstream reservoirs. (derived from BPA's Modified Flows report, 1990).

	Grand Coulee	Power	Return Flows			
Month	Diversion	Demand	Wanapum	Priest Rapids	McNary	Total
j	M_{11}	per cfs	RFM_{1j6}	RFM_{1j7}	RFM_{1j8}	
Jan.	0.0%	120	0.14%	0.40%	0.75%	1.4%
Feb.	0.0%	460	0.13%	0.32%	0.72%	1.3%
Mar.	3.6%	400	0.13%	0.34%	0.94%	1.5%
April	16.2%	340	0.18%	0.49%	1.22%	2.1%
May	16.9%	340	0.18%	0.55%	1.20%	2.1%
June	15.6%	340	0.17%	0.47%	1.29%	2.1%
July	18.2%	295	0.21%	0.51%	1.52%	2.4%
August	14.5%	450	0.25%	0.64%	1.57%	2.7%
Sept.	9.7%	120	0.26%	0.60%	1.65%	2.8%
Oct.	5.3%	460	0.24%	0.66%	1.37%	2.5%
Nov.	0.0%	400	0.18%	0.43%	0.70%	1.5%
Dec.	0.0%	340	0.16%	0.37%	0.58%	1.3%
Total	100%		2.21%	5.78%	13.50%	23.7%

Table 5.5. Estimated change in monthly flow rates (cfs) due to new 221,456 AF water right diversion at Grand Coulee and associated return flows downstream of Grand Coulee.

	Grand Coulee	Return Flows		
Month	Diversion cfs	Wanapum	Priest Rapids	McNary
	$\Delta D_1 x M_{1j}$ /$(1.98 DAY_j)$	$\Delta D_i x RFM_{1j6}$ /$(1.98 DAY_j)$	$\Delta D_i x RFM_{1j7}$ /$(1.98 DAY_j)$	$\Delta D_i x RFM_{1j8}$ /$(1.98 DAY_j)$
Jan.	0.0	5.2	14.8	27.9
Feb.	0.0	5.0	12.8	26.9
Mar.	133.8	4.7	12.6	35.2
April	594.1	6.5	18.4	45.7
April	594.1	6.5	18.4	45.7
May	618.4	6.4	20.4	44.7
June	571.5	6.5	17.4	48.0
July	666.8	7.5	18.4	56.6
August	533.0	8.8	23.1	58.4
August	533.0	8.8	23.1	58.4
Sept.	354.2	9.5	22.5	61.5
Oct.	195.4	8.5	23.9	51.0
Nov.	0.0	6.6	16.0	25.9
Dec.	0.0	6.2	13.2	21.7

C. Hydropower loss calculations for dams below Grand Coulee

Unlike the Columbia Basin Project, the other irrigation projects along the mainstem river do not deliver water to farms located far, and at much higher elevation than, the diversion site. Hence, the pattern of return flows from these diversions is less complicated. We adopt the simple assumption that return flows from diversions below Grand Coulee return to the reservoir from which they originate. Using computations from BPA's (1993a) "Modified Streamflows 1990 Level Irrigation, Columbia River and Coastal Basins 1928-1989", the total estimated return flow for irrigation projects at Chief Joseph through Wanapum is 14.98% of the diverted water, while the estimated return flows from projects at McNary and John Day is 16.4% of the diverted water. Estimated monthly patterns of diversions and return flows for irrigation projects from reservoirs ranging from Chief Joseph dam down to John Day dam are listed in Table 5.6. To obtain the net amount of water diverted from each reservoir, we multiply the each monthly net diversion % times the acre-feet of new diversions (from Table 2.6). Then we convert this to monthly flow, megawatts of power lost, and value of power lost using equation (4) listed above. We use the system power factors (HKSUMS) from Tabled 5.4a &b and prices from Table 5.5. The results for each reservoir are listed in Tables 5.1 through 5.3.

Table 5.6a Monthly System Power Factors[1] (MW/Kcfs) for an average water year, the sum of the HKs (HKSUM) at each dam plus all downstream dams. Average for 1929 – 1978, modeled flows and hydropower under 2000 Biological Opinion.

	Grand Coulee	**Chief Joseph**	**Wells**	**Rocky Reach**	**Rock Island**	**Wanapum**	**Priest Rapids**	**McNary**	**John Day**
Sept.	86.3	61.8	49.0	44.0	37.3	34.4	28.7	22.9	17.7
Oct.	85.7	61.2	48.5	43.6	37.0	34.2	28.4	22.7	17.6
Nov.	85.7	61.4	48.7	43.8	37.2	34.3	28.6	22.9	17.8
Dec.	84.5	60.7	48.0	43.2	36.7	33.9	28.2	22.6	17.6
Jan.	81.5	58.7	46.2	41.6	35.2	32.5	27.0	21.8	17.0
Feb.	82.3	60.1	47.4	42.6	36.1	33.4	27.7	22.2	17.3
Mar.	81.9	60.0	47.3	42.4	35.9	33.1	27.4	21.9	17.2
April 1	78.7	57.0	44.5	39.7	33.3	30.7	25.1	19.7	16.0
April 2	65.5	44.3	31.9	27.6	22.1	19.9	16.8	14.9	12.0
May	61.5	40.5	28.7	24.9	19.8	17.7	14.8	13.1	10.5
June	65.3	42.3	30.1	26.0	20.3	18.2	15.4	13.1	10.4
July	68.8	44.4	32.0	27.8	22.0	19.9	17.2	14.1	10.1
Aug. 1	69.9	45.6	33.0	28.6	22.5	20.3	17.5	14.4	10.0
Aug. 2	71.3	47.2	34.5	29.8	23.3	20.7	17.9	14.6	9.8

[1] These values assume the system operates in compliance with the 1998 biological opinion.

Table 5.6b Dry Year Monthly System Power Factors[1] (MW/Kcfs), the sum of the HKs for each dam plus all downstream dams. (using 1977 water year as the dry year).

	Grand Coulee	**Chief Joseph**	**Wells**	**Rocky Reach**	**Rock Island**	**Wanapum**	**Priest Rapids**	**McNary**	**John Day**
Sept.	84.2	59.4	46.7	42.0	35.6	32.9	27.2	21.7	17.1
Oct.	85.6	60.8	48.1	43.2	36.8	33.9	28.2	22.6	17.4
Nov.	85.5	61.3	48.6	43.7	37.1	34.3	28.6	22.9	17.8
Dec.	84.6	61.3	48.5	43.7	37.1	34.3	28.5	22.9	17.8
Jan.	83.9	61.2	48.5	43.7	37.1	34.3	28.5	22.9	17.8
Feb.	84.5	62.3	49.5	44.4	37.7	34.8	29.1	23.3	18.2
Mar.	84.7	62.4	49.6	44.4	37.8	34.8	29.1	23.3	18.2
April 1	85.4	61.6	48.8	43.7	37.1	34.4	28.6	22.8	17.8
April 2	69.5	45.3	32.6	28.2	22.6	20.3	17.2	15.1	12.1
May	66.6	42.5	30.0	25.8	20.5	18.3	15.2	13.2	10.5
June	68.3	43.7	31.0	26.3	20.1	17.9	14.9	12.2	10.0
July	71.7	46.8	34.1	29.4	23.4	21.3	18.4	15.0	9.7
Aug. 1	71.2	46.9	34.2	29.5	23.3	21.1	18.2	14.8	9.6
Aug. 2	72.1	48.1	35.4	30.5	24.0	21.3	18.4	15.0	9.8

[1] These values assume the system operates in compliance with the 1998 biological opinion.

Table 5.7 Average Monthly Energy Prices, Mid-C Price Forecast 2003-2012 ($/MW hr)

	High Load Hours	**Flat**	**Low Load Hours**
September	40.03	38.54	36.56
October	38.42	35.44	31.50
November	44.19	39.75	33.85
December	43.40	39.89	35.24
January	38.86	35.77	31.67
February	37.86	35.10	31.44
March	34.79	32.33	29.07
April 1	33.69	31.09	27.63
April 2	33.69	31.09	27.63
May	28.29	27.00	25.29
June	26.09	23.40	19.84
July	31.41	29.65	27.31
August 1	35.50	34.55	33.30
August 2	35.50	34.55	33.30

Source: BPA. Spreadsheet from Rob Petty (via A. Perino).

Table 5.8. Distribution of diversions and return flows from reservoirs below Grand Coulee

	Chief Joseph, Wells, Rocky Reach, Rock Island and Wanapum dams			**McNary and John Day**		
Month	**Diversion**	**Return Flow**	**Net Depletion**	**Diversion**	**Return Flow**	**Net Depletion**
SEP	4%	12%	2.20%	11.0%	13.0%	8.9%
OCT	1%	9%	-0.35%	3.0%	12.0%	1.0%
NOV	0%	5%	-0.75%	0.0%	9.0%	-1.5%
DEC	0%	5%	-0.75%	0.0%	8.0%	-1.3%
JAN	0%	4%	-0.60%	0.0%	3.0%	-0.5%
FEB	0%	4%	-0.60%	0.0%	3.0%	-0.5%
MAR	0%	3%	-0.45%	0.0%	3.0%	-0.5%
AP1	1%	2%	0.70%	3.5%	1.5%	3.3%
AP2	1%	2%	0.70%	3.5%	1.5%	3.3%
MAY	17%	11%	15.35%	16.0%	9.0%	14.5%
JUN	28%	14%	25.90%	21.0%	12.0%	19.0%
JUL	31%	15%	28.75%	24.0%	12.0%	22.0%
AG1	9%	7%	7.45%	9.5%	7.5%	8.3%
AG2	9%	7%	7.45%	9.5%	7.5%	8.3%
	100%	100%	85.02%	101.0%	102.0%	84.3%

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CHAPTER 6. EFFECTS ON FLOOD CONTROL

Flood Control is an important use of the regulated Columbia River system. Locations within the Columbia River basin in Idaho, Montana, Washington, and Oregon are particularly vulnerable to flooding.[6] Some proposed methods of operation could increase flood risk to these areas.

As flood waters exceed the river banks and flow onto nearby developed properties, damages occur. Generally, the deeper and longer water stands on structures, the greater the damage. Similarly, greater damage is caused by larger floods which inundate more structures.[7] Flood damages could have severe economic impacts on communities, and flood damages will be different for different types of property. For example, residential structures, commercial property, industrial areas, agricultural land, and public areas will all have different economic setbacks as a result of flood damage. All damage reaches will not necessarily contain all categories of land use. In the event of a flood, further economic impacts would occur in the form of increased spending for emergency aid, including expenditures essential to the preservation of life and property, such as clearance of debris and wreckage, emergency repair or temporary replacement of private and public facilities, evacuation assistance, and the like.[8] Flood damage potential is greatest in the lower Columbia from the Portland-Vancouver area to the mouth of the river. This area is susceptible to both rain-produced and snowmelt floods.

A. How the System Works

There are two principal flood seasons in the Pacific Northwest. November through March is the rain-produced flood period that most frequently occurs on streams west of the Cascade mountain range. May through July is the snowmelt flood period which predominates east of the Cascades. The worst snowmelt floods occur when extended periods of warmer weather combine with a large accumulation of winter snow. Many streams in the basin remain uncontrolled; however, reservoirs on the major rivers reduce flood damage in many areas.[9]

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[6] U.S. Army Corps of Engineers, Columbia River System Operation Review

[7] U.S. Army Corps of Engineers, Columbia River System Operation Review

[8] U.S. Army Corps of Engineers, Columbia River System Operation Review

[9] BPA, The Columbia River System: The Inside Story

The objective of any flood control operation is to capture enough runoff in reservoirs to keep streamflows from reaching damaging levels. Timing is critical and there is a significant amount of uncertainty. When runoff is highest, reservoir levels must be reduced the most. The greater source of flood potential—snowmelt—can be predicted several months in advance. Thus, flood control space is made available primarily in those months when flood risk exists, and the amount of storage space needed depends on expected runoff based on long-term weather forecasts. This makes it possible to use reservoir space for other uses such as hydropower, fish flows, irrigation, and recreation during periods of low flood risk. The flood control objective is two-fold: operating the total reservoir system to minimize damaging flows on the lower Columbia River, and operating individual reservoirs to minimize damage to local areas.[10]

System operators have developed flood control rule curves specifying the amount of storage that must be evacuated during the fall and winter to meet the objectives above. These rule curves have a fixed component and a variable component. The fixed component typically defines operation from September through December when less predictable rainfall floods occur. This curve is based on a statistical analysis of historical events because accurate forecasts of runoff are not available. The variable component of flood control rule curves defines operation from January through April. Forecasts of seasonal volume runoff become available in January, and these forecasts define the variable portion of the rule curve. It is based on the runoff volume expected to occur and thus indicates the amount of storage space needed to control floods for the snowmelt season. Uncertainty of weather forecasts is an issue, and for this reason flood control curves are updated monthly as revised forecasts become available, somewhat reducing the amount of uncertainty.[11]

To summarize the reservoir operation system, there are three seasons of operation. In September through December, there is a fixed drawdown based on historical patterns when the volume of the next spring runoff is unknown. From January through April there is a variable drawdown based on spring runoff forecasts that guide operations through the runoff and refill season. From April through August, operators focus on capturing enough runoff to refill reservoirs by the end of July. When runoff is low, reservoirs may not refill and operations will

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[10] BPA, The Columbia River System: The Inside Story

[11] BPA, The Columbia River System: The Inside Story

be shaped by how low reservoir levels are on July 31.[12] Flood control involves storage reservoir drawdown in the autumn/winter, and refill in the spring. Additional withdrawals from the river will reduce flow into reservoirs, which will not negatively affect flood control.

B. Impact of the Scenarios on the System

All scenarios in the report involve increased diversion of Columbia River water, which won't be detrimental to flood control. Increased diversions mean leaving less water in-stream, which if anything, might improve the opportunity for flood control. This improved opportunity might be imperceptible as pools will still maintain MOP by federal mandate for functions such as anadromous fish passage.

The greatest chance for damages from flooding would occur in scenario 5, the no action scenario. Under this scenario, the existing flood control management strategy should be examined to see if any economic impacts will occur as a result of potential flood damages to communities along the Columbia River.

The lower Snake River dams were not and are not operated to provide flood control benefits because flood control is not a congressionally authorized project use.[13] The projects are physically capable of providing a minor flood control benefit under a partial drawdown operation strategy, but only when coupled with major reconstruction of the projects. Reconstruction would be needed to continue current congressionally authorized uses and operation of fish passage facilities. The Dworshak project located upstream on the Clearwater River currently provides congressionally authorized flood control benefits for the lower Snake River and further downstream on the Columbia River.[14]

The major elements of the Columbia River flood control system occur at the following dams: Mica, Arrow, Duncan, Libby, Hungry Horse, Grand Coulee, Dworshak, Brownlee, and John Day. Only two of these, Grand Coulee and John Day are directly relevant to the mainstem of the Columbia in Washington State. All others are located outside of Washington State, and all are located on tributaries, except for Mica and Arrow which are on the mainstem in British

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[12] BPA, The Columbia River System: The Inside Story

[13] Lower Snake River Juvenile Salmon Migration Study

[14] U.S. Army Corps of Engineers, Columbia River System Operation Review

Columbia. All of these dams located outside of Washington State provide flood control for the entire downstream system, but Grand Coulee and John Day dams have the most direct effects to this study. Grand Coulee provides for 5.2 MAF and John Day provides for .5 MAF of primary flood control space.[15]

Another concern is the trade-off that occurs between flood control and other purposes, such as hydropower. Flood control became the major objective of the river system after the tragic flood of 1948 that destroyed Vanport, Oregon.[16] Some would argue that the law regarding flood control is too conservative. For example, leaving less space available in pools for flood control purposes leaves areas more susceptible to flood damages, but provides more benefits in the form of increased hydropower capabilities. Being less conservative with respect to flood control in a year when there is a very low probability of flooding will lead to net benefits in the form of increased hydropower, with no costs to flood control. However, there is significant uncertainty. A major problem with loosening the flood control standards is that the decision to leave more water in dams for other benefits will be based on a long-term weather forecast which is subject to error. If a dry year is predicted, and water is left in pools for other benefits, and the year is wetter than predicted, flooding may occur leading to astronomical damages compared to the relatively modest benefits from less stringent flood control standards. Conversely, if a wet year is predicted, and pools are drawn down in anticipation of high water levels, and the year is drier than predicted, there could be a significant detrimental affect on other uses, such as anadromous fish populations.

The Army Corps of Engineers (Corps) has examined this topic in more detail by describing the impact to Columbia River system flood control operation resulting from modifying the flood control requirements at Libby dam and Hungry Horse dam. This modified flood control regulation is called VARQ and was designed to improve the multi-purpose operation of the reservoirs by defining a more flexible flood control operation.[17] Columbia River management activities have changed as a result of the Endangered Species Act (ESA). Flow

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[15] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

[16] BPA, The Columbia River System: The Inside Story

[17] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

augmentation operations have been described by Biological Opinions resulting in releases of water from Libby and Hungry Horse during the annual reservoir refill period in excess of that envisioned in the current flood control plans. As a result, the likelihood and frequency of refill has been reduced. The Corps developed the VARQ flood control procedure to address this imbalance. VARQ reduces system flood control space required at Libby and Hungry Horse and allows outflows during refill to vary based on the water supply forecast. VARQ can accommodate the higher releases required for endangered species while maintaining current flood protection and improving the ability to refill the reservoirs.[18] However, the Corps will not increase the flood risk without significant study of the impacts, and a significant study will be a costly endeavor. The Corp's Walla Walla district is in the process of writing a Reconnaissance Report on the Columbia River's flood control system. Whether or not the Corps will initiate an extensive significant study partly depends on the recommendations of the Reconnaissance Report.

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[18] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

CHAPTER 7. EFFECTS ON RIVER NAVIGATION

Navigation on the Columbia and Snake Rivers has for many years provided a route of access for barge and vessel traffic into and from the Columbia and Snake River basins. Historically, the recognition of the economic importance of a well functioning navigation system led to early navigation improvements in the form of the construction of dams and locks on the Columbia and Snake Rivers in the 20th Century.[19]

A. How the System Works

The Columbia-Snake Inland Waterway is a 465-mile-long system formed by eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The waterway provides waterborne navigation up and down the river from Lewiston, Idaho, to the Pacific Ocean. The system is used for commodity shipments by barge, as well as smaller commercial and recreational vessels, from inland areas of the Northwest and as far east as North Dakota.[20] Dams along the Columbia upstream of McNary Dam are irrelevant to navigation because those dams do not have lock passage facilities. The Columbia-Snake River navigation system consists of two segments: the downstream portion below Bonneville Dam, which provides a deep-draft shipping channel, and the upstream portion above Bonneville Dam, which is a shallow-draft channel with a series of navigation locks.

The presence of the Columbia-Snake River system has led to the development of a large and significant river-based transportation industry in the region. Port district managed facilities and various other public and private entities are located on the pools created by the dam system. The number of port facilities on all eight reservoirs totals 54, with 34 on the lower Columbia River (McNary and below) and 20 on the lower Snake River (Lower Granite Reservoir and below). The geographic distribution of port facilities reflects concentration of shipping activity near Lewiston on the Lower Granite Pool and Pasco on the McNary Pool. Grain terminals are the most common facilities accounting for nearly half of all terminals within the study area, and

[19] U.S. Army Corps of Engineers, Columbia River SOR

[20] Lower Snake River Juvenile Salmon Migration Feasibility Report

minimum water depths or minimum operating pool (MOP) alongside these facilities range from 10 to 40 feet for active facilities.[21]

The Columbia River authorized ship channel begins at the Columbia River entrance (River Mile [RM] 4) and extends through the Tri-Cities area in Washington. Authorization provides for a 40-foot-deep, 600-foot-wide ship channel from the Columbia River Bar to Vancouver, Washington (RM 106). From Vancouver to The Dalles Dam, the authorized channel is 27 feet deep and 300 feet wide, however, the channel is typically dredged only to 17 feet reflecting the maximum depth requirement from commercial traffic through this reach of the river. A 14-foot-deep channel 250 feet wide is maintained from The Dalles Dam, through McNary Dam, and up to the various ports in the vicinity of the Tri-Cities, Washington and from the mouth of the Snake River to Lewiston, Idaho.[22]

Optimal conditions for the navigation of the system are those which (a) allow for the use of the channels, navigation locks, and associated facilities at or in excess of their present level of use, (b) without increased maintenance costs, (c) or compromised safety of vessels. Since the largest vessels using the waterway above Bonneville Dam are barges used to haul grain, a minimum "optimal condition" is one that allows a vessel with a 14-foot draft to move unimpeded through the locks of the dams on the Columbia and Snake Rivers.[23]

The locks on the Columbia and Snake River dams lift or lower vessels, on average, 100 feet above the lock's downstream and/or upstream entrances. Each lock has an operating range determined not only by its hydraulic lift but also by the depth of the sill, the base of the navigation lock, at the upstream and downstream entrances to the locks.[24]

The passage of commercial or recreational vessels in the Columbia-Snake River system is limited by sill depths at the navigation locks. At most of the projects upstream sills are at 15 feet below relative to MOP. MOP provides the clearance needed for barge drafting 14 feet, the typical draft barges operating in the fleet of vessels on the system.[25]

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[21] U.S. Army Corps of Engineers, Columbia River SOR

[22] U.S. Army Corps of Engineers, Columbia River SOR

[23] U.S. Army Corps of Engineers, Columbia River SOR

[24] U.S. Army Corps of Engineers, Columbia River SOR

[25] U.S. Army Corps of Engineers, Columbia River SOR

B. Magnitude of Waterborne Commerce

Waterborne Commerce is among the most valuable use of navigation locks along the system. Consider first the Columbia River deep-draft channel below Bonneville dam. Within the region, a variety of commodities are produced. Of those industries within the region that generates waterborne commerce, agriculture dominates, particularly with respect to production of grains such as wheat and barley. Corn, which is produced primarily outside of the region, represents a significant volume of shipments from export terminals on the lower Columbia River. Other industries that use water to transport products include aluminum, pulp and paper, petroleum products, and logs and wood products. Wheat and corn represent the majority of total commodities shipped on the deep draft segment of the Columbia River channel. Some other notable products are automobiles, containerized products, and chemicals. Countries involved in the region's export trade are Japan, Korea, and Taiwan, as well as other Pacific Rim countries.[26]

Products shipped on the shallow draft segment of the system consist primarily of grain, wood products, logs, petroleum, chemicals, and other agricultural products. Bulk shipments make up much of the waterborne traffic on the upstream channel. A number of commodities, principally non-grain agricultural and food products and paper products, are shipped via container. Nearly all of the downriver-bound container shipments are destined for Portland, Oregon, with the small fraction of remaining goods going to Vancouver, Washington. The bulk of upriver barge shipments have been made up of petroleum products.[27]

Commodity movement on the lower Snake River is dominated by grain (mostly wheat and barley), which comprised of 75% of the tonnage passing through Ice Harbor lock from 1992 to 1997. During the same period, wood products, including wood chips and logs, accounted for 16%, petroleum products accounted for another 3%, paper and pulp accounted for 2%, and all other commodities accounted for the remaining 3%.

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[26] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

[27] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

Table 7.1 Domestic Traffic for Selected U.S. Inland Waterways in 2001

Waterway	Length in Miles	Millions of Short Tons
Columbia River System, OR, WA, and ID	596	20.2
Vancouver, WA to The Dalles, OR	85	9.8
The Dalles Dam to McNary Lock and Dam	100	8.9
Above McNary L & D to Kennewick, WA	39	6.7

Source: Waterborne Commerce Statistical Center

C. Increased Diversions and Flow Impacts

Consider the largest amont of water that could be diverted as a result of the management scenarios. 1 MAF of additional withdrawals will reduce river flows. A summary of the resulting diversions (based on an extrapolation of existing applications for water rights) by pool is shown below in both AF and cubic-feet per second (cfs).

Table 7.2

Pool	New Water Diversions - Volume (Acre-Feet)	New Water Diversions - Flow (cfs)
Bonneville	0	0
The Dalles	0	0
John Day	309,983	429
McNary	311,143	431
Priest Rapids	0	0
Wannapum	4,135	6
Rock Island	13,768	19
Rocky Reach	17,263	24
Wells	120,592	167
Chief Joseph	1,659	2
Grand Coulee	221,456	306
Total	1,000,000	1,384

The water will not be diverted all at once—the right holder will choose to divert certain amounts over the year based on the purpose of use. Most water is used for irrigation, so the typical pattern of diversions follows a distribution in which the largest diversions occur in the summer months of June, July, and August. Other users of water include municipalities, industries, and domestic users. Although these users might also follow a seasonal distribution, it is certainly less extreme than that of irrigation water users. The distribution of diversion was broken into three slightly different groups: the river above Priest Rapids pool, the river below Priest Rapids pool, and the Columbia Basin Project (CBP) at Grand Coulee. This is the same pattern of distribution that was considered in Chapter 5, as displayed in Table 5.3

The three diversionary distributions reflect the nature of crops grown in the regions, the climatic conditions, and the type of water users in the region. Pools above the navigable waters of the Columbia need to be considered because diversions upstream will reduce flow of the entire downstream system.

There will also be return flows from upstream diversions to different locations downstream and at different times. The timing of return flow is a difficult question to consider. For purposes of this study, return flow occurs on a relatively short time frame. Where the return flow occurs is also a difficult question that depends on the watershed, geography and geology of the region water was diverted from. Depletion is defined as diversion minus return flow. This means that in a time when diversions are low, depletion might be negative if return flow is larger than the amount of diversion.

Additionally, there will be return flows from the Columbia Basin Project that pumps water out of Bank's Lake. Return flows are assumed to occur at three pools downstream of the project: Wanapum, Priest Rapids, and McNary pools. For purposes of navigation, the return flows will be summed to McNary pool, where navigation is relevant. Table 5.4 above summarizes the diversions and return flow for the Columbia Basin Project.

To summarize how these tables of diversions, return flows, and depletion will be used to create a table of monthly flows, an aggregate flow will be created at each dam which incorporates the mainstem flow, minus upstream diversions, plus return flows from local diversions and from the CBP diversion on a monthly basis. Therefore at McNary, where navigation becomes relevant, we will have an aggregate flow based on both local and CBP return flows—essentially a flow based on all upstream depletions. Flows will be calculated by determining net depletion upstream of McNary pool from the three distributions above. Depletions from Grand Coulee will be added to depletions from Chief Joseph thru Priest Rapids Dams. Then we add the depletions at McNary itself to the total. Convert this total to cfs for each month and the result is change in flows on a monthly basis.

We will begin by examining flows by choosing a low flow year where additional diversions might create a problem for the navigation system. The drought year 1977 was chosen as a low water year. The flows from that year are based on a model from John Fazio, and are meant to be approximate monthly flows only. Below is a table showing flows at McNary and below for the year 1977.

Table 7.6 Flows WITHOUT additional diversions, 1977

Month	McNary	John Day	The Dalles	Bonneville
Sept	149,224	143,354	148,188	155,434
Oct	127,343	122,136	127,112	133,493
Nov	112,270	109,550	115,709	121,136
Dec	124,063	120,091	125,480	133,837
Jan	122,722	118,303	123,618	131,961
Feb	88,906	84,694	89,335	94,571
March	86,551	82,658	87,331	94,106
April	132,534	132,188	136,323	143,886
May	193,246	190,653	195,649	200,324
June	156,263	152,128	156,439	163,355
July	114,908	109,250	113,336	118,892
Aug	120,262	114,841	118,905	125,037

Now a table of flow with the 1 MAF of additional diversions is created taking into account both diversions and aggregate return flow. It is shown below.

Table 7.7 Flows WITH 1 MAF of additional diversions, 1977

Month	McNary	John Day	The Dalles	Bonneville
Sept	148,435	142,102	146,936	154,182
Oct	127,189	121,930	126,906	133,287
Nov	112,416	109,773	115,932	121,359
Dec	124,189	120,283	125,672	134,029
Jan	122,809	118,415	123,730	132,073
Feb	88,997	84,813	89,454	94,690
March	86,507	82,639	87,312	94,087
April	131,617	130,927	135,062	142,625
May	191,577	188,250	193,246	197,921
June	154,071	148,942	153,253	160,169
July	112,478	105,708	109,794	115,350
Aug	118,998	113,157	117,221	123,353

Now, with the initial flows and the reduced flows due to additional diversions, we can calculate the percentage change in flows for the navigable waters of the shallow draft portion of the river and notice that there is a very small percentage decrease in river flows, which surely won’t affect the navigation system.

This summary of flow changes and its impacts on the navigation system has shown that the diversion in question results in very modest changes in river flow. Therefore, the river height will not be affected for two reasons. First, flows help to determine stage height. If flow is not reduced substantially, neither will river height. Second, river height can be and is controlled by the operation of the dams. If the river height is not affected by the diversions, the shallow draft navigation system will not be affected.

Table 7.8 % Change in Flows with Additional Diversions

Month	McNary	John Day	The Dalles	Bonneville
Sept	-0.53%	-0.87%	-0.85%	-0.81%
Oct	-0.12%	-0.17%	-0.16%	-0.15%
Nov	0.13%	0.20%	0.19%	0.18%
Dec	0.10%	0.16%	0.15%	0.14%
Jan	0.07%	0.09%	0.09%	0.08%
Feb	0.10%	0.14%	0.13%	0.13%
March	-0.05%	-0.02%	-0.02%	-0.02%
April	-0.69%	-0.95%	-0.92%	-0.88%
May	-0.86%	-1.26%	-1.23%	-1.20%
June	-1.40%	-2.09%	-2.04%	-1.95%
July	-2.11%	-3.24%	-3.13%	-2.98%
Aug	-1.05%	-1.47%	-1.42%	-1.35%

However, the question remains: At what flow level will the navigation system be affected? Due to the dependent nature of flow and river height, at some point, if flows are low enough the river height can not be controlled by the operation of the dams and the navigation system will not be operational. It is unclear whether there is a good answer to the following question: What is the minimum flow required to maintain the navigation system Minimum Operating Pool level of 14 feet?

Below Bonneville dam the authorized channel increases in depth which allows deep draft ocean going vessels to access the ports at Portland, OR and Vancouver, WA. Channel depths on the deep draft portion of the river depend on more than just river flow; depths will depend on spillage from dams (flow), tidal currents, surface water runoff, and melting snow. Below Longview, WA the deep draft channel depth is driven almost entirely by tidal currents, implying that decreased flows out of Bonneville is only a concern between Longview and Portland. For that section of the river, navigational disruptions might occur if the flow out of

Bonneville dam falls below 70,000 cfs.[28] The reduced flows resulting from the increased diversions examined in this study will not have an impact on the navigation system. Referring to Table 7.7, the lowest flow in this dry year occurs in March, when the resulting flow with new diversions is 90,000 cfs, well above the flow at which navigational impacts will occur.

D. Impact of the Scenarios on Navigation

For many of the scenarios examined there is likely to be no economic effect on the current navigation system should new water be diverted for out-of-stream use. Consider the least conservative scenario in terms of water use, scenario 1, in which 1 MAF of additional water is to be made available for out-of-stream use every year. If there is no economic effect on the navigation system in this scenario, there will surely be no economic effect on more water conservative scenarios, as larger amounts water is to be left in-stream in scenarios 2 through 5.

There are other things to consider in terms of economic value besides commercial barge traffic. The first thing to note is that if any one navigation lock is unable to operate due to insufficient water levels on the river because of the additional water withdrawals, the entire system is shut down upstream of that particular lock, and there will be no economic benefits from the navigation system upstream. Should the navigation system cease to operate due to substantial decreases of in-stream flow, there are alternative modes of transportation. With loss of access to the Columbia-Snake River system, in the short-run it is likely that shipments would be delayed because the infrastructure required to support a short-run switch to a new mode of transportation does not exist. In the long-run, commodities would move by the next least costly available mode, such as rail direct to export elevators on the lower Columbia or by truck to river elevators located on the pools. These alternative modes of transportation are fraught with infrastructure issues and costs. Expenditures on transportation infrastructure would be required to increase the capacity of the system prior to additional diversions of water if the Columbia-Snake River system were to become no longer operational.[29]

Secondly, in a low water year, lock operators will wait until the lock is full of vessels before allowing passage. In the case of commercial barges, this is not an issue, because the

[28] Per conversation with Army Corps of Engineers hydrologist Peter Brooks.

[29] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

barges are designed to fit one tow per lock. A tow enters the lock, fills it, and is permitted to pass through. However, in the case of smaller recreational vessels, waterborne travelers need to wait until the lock is filled with other smaller vessels before passage is allowed in order to maintain pool levels in a low water year. In a high water flow year, this is not a problem for smaller vessels as there are sufficient pool levels, and vessels are allowed through on demand. During the time that recreational lockages are restricted, the locks are typically operated on a published schedule. In 2001, the U.S. Army Corps of Engineers set limited lockage schedules at all lower Snake River and Columbia River dams. The schedule applied only to recreational boats from May 15 to September 15. Upstream lockages were set for 9 A.M., 2 P.M., and 7 P.M., while downstream lockages were set for 9:30 A.M., 2:30 P.M., and 7:30 P.M. This reduced the amount of water lost when boats passed through, and provided more water for power used in the Pacific Northwest. Because the locks are operated on a published schedule, boaters are able to time their activities accordingly, and for that reason there is unlikely to be any delay and therefore no lost time to the boater as a result of the added constraint. *[Are there records available on the volume of recreational traffic that occurred? Is there a trigger rule about when lockages will be restricted?]*

Lastly, if there is a significant decrease in river levels such that barge traffic is impeded due to the increased diversions could mean that barges have to lightload a tow, thus increasing transportation costs. In this case, navigation would be maintained, but costs increase as barges haul fewer goods and make more trips.

Consider the extrapolation of scenario 1 in which future surface water (SW) diversions are extrapolated from existing SW permits, certificates, and applications. Assume that Ecology grants all existing SW applications accounting for approximately 348 KAF.[30] Further assume that Ecology grants 652 KAF future applications to total 1 MAF additional Columbia River diversions.

The largest percentage increase in diversions would occur at Wells dam, which nearly triples the amount of diversions based on current water rights. This dam is far enough upstream to allow for a substantial amount of return flow to the lower Columbia where navigation is

[30] Based on cubic feet per second (cfs) as stated on the application multiplied by 1.98 Acre Feet per 1 cfs, multiplied by 183 days (6 months) for an irrigation season.

relevant. The other significant increases in diversions based on this extrapolation are McNary and John Day dams that both increase by about 50%. Both of these increased diversions are a concern to the navigation system as they are substantial diversions and are located on the lower Columbia. The lower Columbia is a much larger, deeper, and wider river than the upstream mainstem, and because of this, could allow for more diversions. Return flow won't be much of a factor because the dams are further downstream. Additional diversions of this distribution will not affect the navigation system because the amount of additional diversions is quite small relative to the total amount of water in the system, and therefore would not have a measurable impact on navigation. Reduced flows as a result of additional diversions have been developed in this chapter, and the resulting changes in flows were shown to be miniscule. Because there is no affect on the least water conservative scenario, there will not be any affect on more water conservative scenarios, as more water is being left in-stream. Hence, there will be no affect on navigation in all scenarios examined in this study.

In summary, there is unlikely to be any economic affects on the current Columbia-Snake River navigation system from additional withdrawals of mainstem water due to the relatively small amount of increased diversions. Even in the least conservative scenario with respect to water, scenario 1, river levels will only be drawn down modestly. Because of this, the current navigation system will not be affected in scenario 1. Scenarios 2 through 5 involve the diversion of less and less water, and consequently will not be affected either.

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CHAPTER 8. ECONOMIC EFFECTS ON COMMERCIAL AND RECREATIONAL FISHING

Additional diversions of water from the mainstem Columbia River will slightly reduce the average river flows (as indicated above in Chapters 5 and 7) and that could effect flows needed to conserve salmon populations that are listed as threatened or endangered under the Endangered Species Act. As noted in Chapter 2, the risks to salmon species are being assessed by a National Research Council Committee sponsored by Washington Department of Ecology. Because this report precedes the NRC report, we are unable to use the results of their assessment in this study. There have been a substantial number of studies aimed at identifying the relationships between river flow and survival of out-migrating smolts, and some additional studies have attempted to establish what flow conditions improve survival up adult salmon during their upstream migrations. As a consequence, this report will not attempt to estimate specific changes in economics values or impacts associated with effects of the water rights allocations on the fish stocks. Instead, this study provides a review of the concepts, methods, and existing literature concerning economic value of commercial and recreational fisheries for Pacific salmon of the Columbia basin.

A. Trends in the Commercial Pacific Salmon Fishery Values

During the past two decades the major trend affecting the commercial salmon fishery was the burgeoning supply of fresh salmon from the salmon farming industry. As indicated in Figure 1 below, the aggregate harvest of Pacific salmon remained at relatively high levels (mainly in Alaska), while world farmed production grew rapidly, fainally exceeding the total fishery harvest. One major consequence of this development was a substantial drop in the price paid to fishermen for salmon, confirming that market demand is negatively related to price. This drop in price affects both farmed salmon and fishery harvests of salmon, and was made possible by the rapid technological advances in salmon farming that fostered lower production costs and effective marketing techniques. The average market value of farmed salmon dropped from roughly $6,000/metric ton to less than $3,000/metric ton between 1987 and 2001. This world-wide trend in price is the major cause of reduced earnings and crisis in salmon fishing communities in Alaska and the Pacific Northwest.

Many salmon of Columbia river origin are caught in the ocean fishery north of Cape Falcon, Oregon, and in the fishery occurring in the river itself. Harvests in these fisheries fluctuated widely around a declining trend, until an upturn in catch during the last two years. During the period from 1987 to 2002, the average exvessel price of ocean-caught salmon (coho and chinook combined) dropped from roughly $5/lb. to just over $1/lb. (Figure 8.2) Similarly, the in-river gillnet commercial salmon fishery (see Figure 8.3) has suffered a substantial decline in total volume of harvests and in price since the mid-1980s. The reduced harvests during the mid-1990s did not bring the positive price response that one would typically expect, mainly because the Pacific coast salmon are sold to the world market which is flooded with farmed salmon and Alaska's Pacific salmon.

Looking in more detail at prices for species and sub-species of salmon (Table 8.1), we can readily see that, while all the prices fell substantially, the price for spring chinook caught in the river have held up to a respectable $2.50 per pound, the other prices have fallen rather drastically.

Table 8.1 Average Price per Pound (2002 $). By Species, all Columbia River Commercial Fisheries.

	Chinook			Coho	Chum
	Spring	Fall	Tule		
1988-1997	$4.07	$1.23	$0.39	$1.32	$0.43
1998	$2.75	$0.58	$0.20	$0.71	
1999	$2.97	$0.71	$0.09	$0.89	$0.24
2000	$2.66	$0.75	$0.13	$0.54	$0.22
2001	$2.08	$0.32	$0.13	$0.27	$0.18
2002	$2.50	$0.27	$0.11	$0.32	

Source: Pacific Fishery Management Council. 2003. Pacific Salmon Fishery Management Plan. Chapter IV "socioeconomic Assessment of the 2002 Ocean Salmon Fisheries". Portland, OR.

Incomes from fishing are reckoned as gross exvessel revenue minus costs of fishing fleet operation and maintenance. Given the amounts of money and effort spent on management, augmentation, and restoration of the salmon fishery, remarkably little effort has been expended to collect the information necessary to gauge the incomes earned in the fishery. Hence, most economic assessments of the fishery focus on gross sales value of the fish, with occasional attention to rough estimates of earnings. Some studies (Rettig and McCarl 1984, Radtke and Davis 1994) have attempted to assess the net earnings from salmon fishing, usually by looking at a sample of vessels and roughly estimating the proportion of revenues that go into direct costs of fishing. In the early and mid-1990s, it was typical to gauge the incomes earned as roughly 50% of the gross sales value of the fish (Huppert, et al. 1996). However, with the substantial drop in prices recently, and assuming that fishing cost have remained constant or increased somewhat, one would have to conclude that there is now little or no net income being generated by the commercial fishery. Only the spring chinook price is still greater than 50% of the average price during 1988-1997 (Table 8.1).

The price trends in commercial fishing suggest that harvests of Pacific salmon from the Columbia River or ocean areas will make small contributions to the value of seafood supply and to local incomes in the future. Further, any enhancement in run sizes for commercial harvests, whether due to hatchery operations or other factors, will make relatively small contributions to the economic value of commercial fishing.

B. Trends in the Recreational Fishery

The recreational fishery supported by Columbia river salmon includes the ocean fishery north of Cape Falcon, the estuary and lower river fishery, and various fisheries farther upstream and in tributaries. The ocean and lower river fisheries have been highly variable, both in terms of catch and level of participation (as measured by annual angler trips taken). The ocean recreational catch averaged 137,000 fish (coho plus chinook) during 1986-2002, while varying between 150,000 - 200,000 in the late 1980s and early 1990s, dropping to zero in 1994 and recovering to a respectable 232,000 in 2001. The lower river and estuary fishery had an average annual catch of 142,000 fish during 1981-2000. Like the ocean fishery, the river fishery catch was relatively high in the late 1980s and early 1990s, dropped to a record low in 1994, and has recovered to about half of the earlier high levels in 2000. Recreational catch data for the river has not been released yet for 2001 and 2002.

While the fishery agencies do not regularly monitor the economic value of the recreational fishery, it is typically the case that overall expenditure on recreational fishing is closely correlated with trips taken. The expenditures per trip are largely unrelated to actual catch of salmon. On the other hand, studies of economic value of fishing trips to anglers (e.g. Huppert 1989) suggest that higher catch rates (catch per fishing trip) increase the demand for, and value of fishing. Hence, a rough interpretation of the available data suggests that trends in angler trips are driven, at least in part, by trends in catch/trip – a variable which, in turn, is influenced by fish abundance and bag limits. Hence, it is unsurprising that total angler trips is positively correlated with catch/trip (as depicted in Figures 8.4).

Economists occasionally execute and analyze economic surveys of recreational salmon fishers to determine the net value of recreational fishing (i.e. the value to anglers of fishing trips minus the cost of taking those trips). The most directly relevant study for Columbia River salmon fishing is a 12-year-old study by Olsen, Richards, and Scott (1991). In that study, the authors determine that average net value per fishing trip in 1989 was $111.46 ($147.63 in 2002 $) in the Columbia river basin, and $89.47 ($118.50 in 2002 $) in the Oregon-Washington coastal fishery. While these values will undoubtedly vary over time (especially as catch rate varies), we could roughly gauge the value of the recreational fishery by multiplying angler days by this estimated average value. This procedure yields an average annual value of $11 million in the No. of Cape Falcon ocean recreational salmon fishery (using data for 1986-2002), and an annual value of $27.3 million for the lower river/estuary recreational fishery (using recorded trips for 1981-2000).

In considering the value of changes in the size of the salmon runs, one could assume that the allowable catch increases with the run size, and that number of angler trips increases in proportion. This would be really accurate only if allowable recreational catch is a constant fraction of total run and angler catch/trip is unaffected by run size. Given the average catch/trip of 1.13 in the Columbia river, this procedure says that for each increase in 1 fish caught, the recreational could increase by (1/1.13) = 0.89 trips, and the value of recreational fishing in the river would increase by 0.89*$149.63 = $131.20. The equivalent value for increased harvest of ocean salmon would be (1/1.14)*$118.50 = $84.4. To obtain a rough measure of recreational value associated with increasing (or decreasing) salmon/steelhead run sizes we would also have to know the fishing mortality rate (fraction of run caught). For example, if 33% of the fish run is caught by recreational anglers, then the change in recreational value due to a change in run size could be roughly estimated as $84.4*.333 = $28.10 times the change in run size.

As noted above, negative economic effects of additional Columbia river diversions could occur if decreased flows in the river (especially during spring and summer) cause increased mortality of juvenile salmon migrating downriver and adult salmon migrating upriver. The review of economic values contained in this chapter could be used to assess the economic values gained or lost as a result of the additional water diversions, based upon a thorough and objectively reviewed scientific report detailing the mortality effects.

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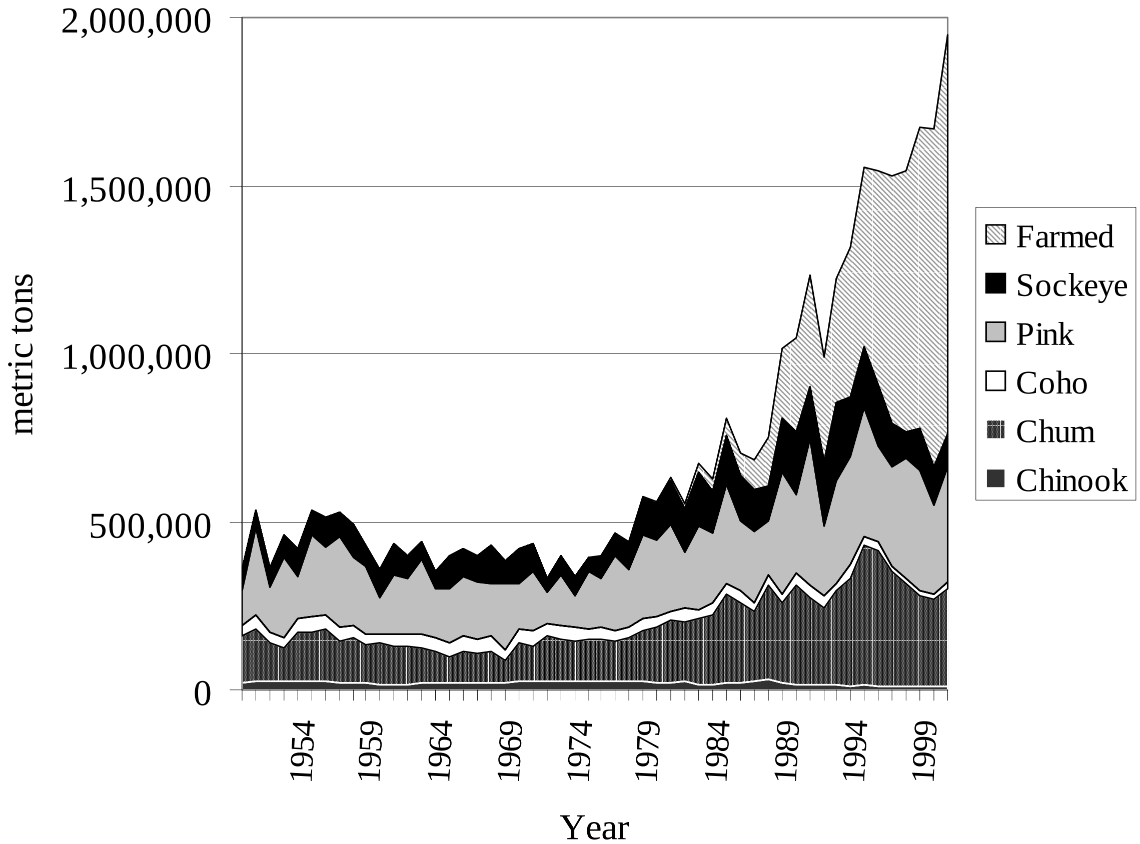

Figure 8.1. Pacific Salmon Harvest and World Farmed Salmon Production.

Source: FAO FishStats database, July 2003.

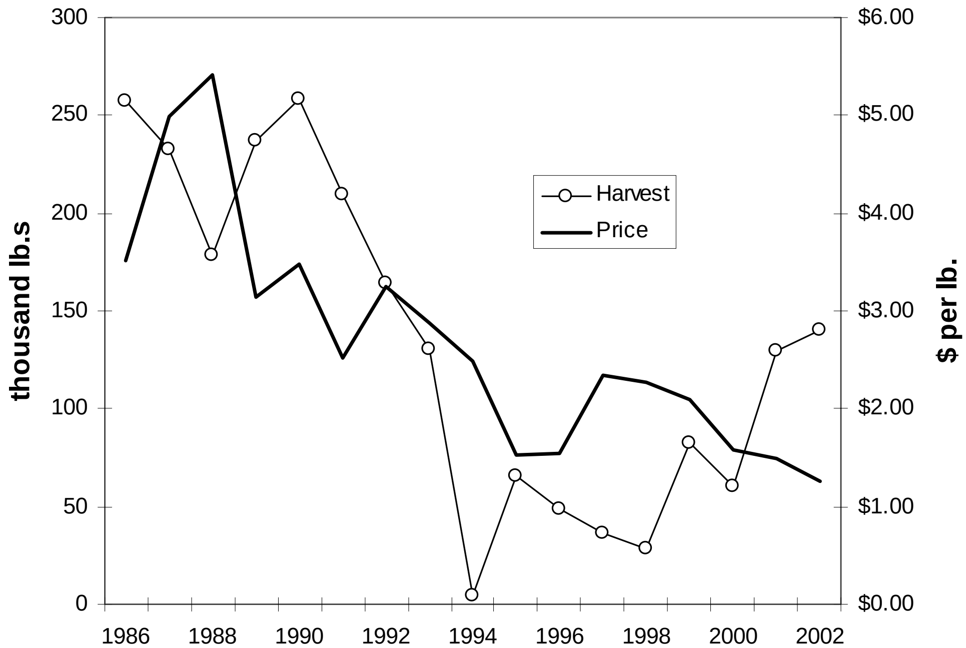

Figure 8.2. US Ocean Salmon Fishery north of Cape Falcon. Total fish caught and exvessel price/lb. Source: PFMC Pacific Salmon Management Plan 2003. Append. A

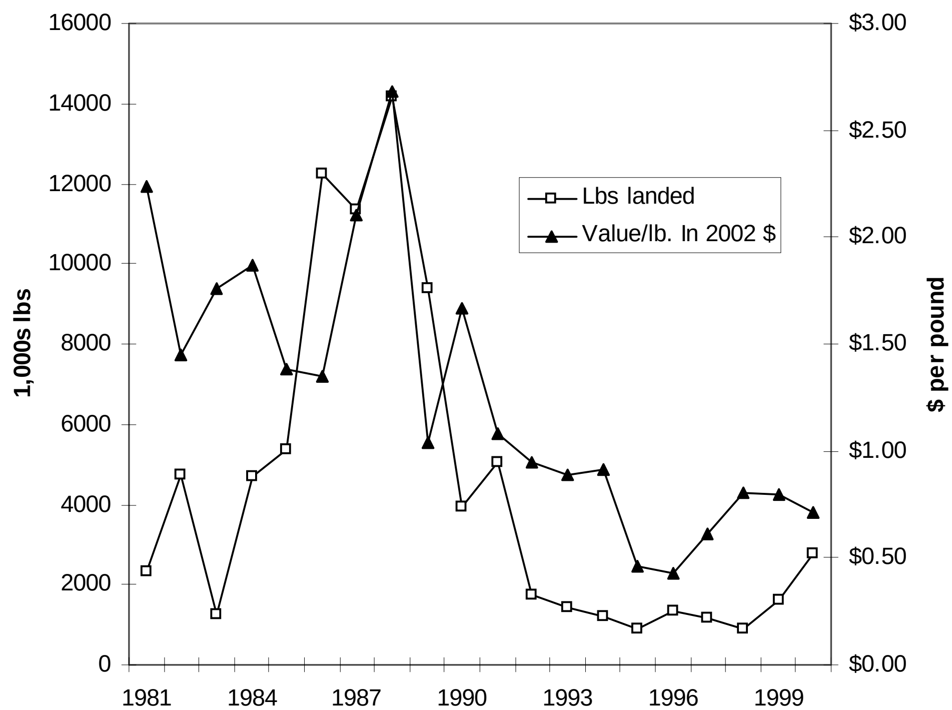

Figure 8.3. Columbia River Commercial Salmon Fishery, above and below Bonneville dam (Zones 1-6), average price per pound for coho and chinook salmon combined.
Source: WDFW and OPDFW. 2002. Status Report: Columbia River Fish Runs and Fisheries

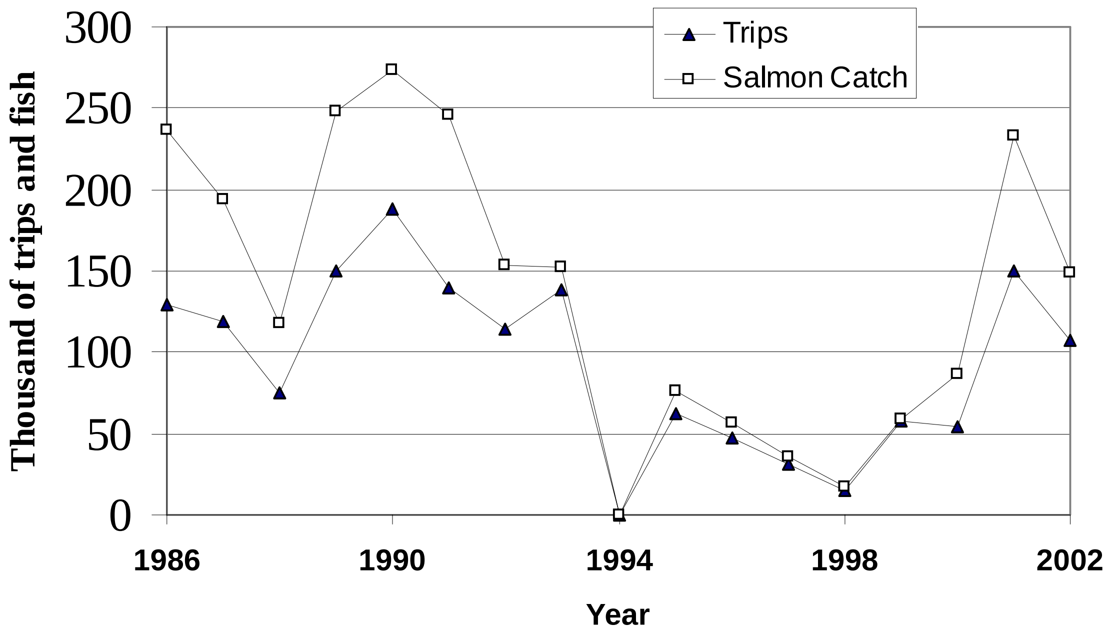

Figure 8.4. Ocean Recreational Salmon Fishery north of Cape Falcon, Oregon.

Source: PFMC Pacific Salmon Management Plan 2003. Append. A

CHAPTER 9. REGIONAL AND SECONDARY IMPACTS OF CRI SCENARIOS

Draft: November 9, 2003

We have used the 1987 Washington Input-Output model to estimate economic impacts of the CRI agriculture and electrical power production scenarios.[31] This model contains 62 sectors, including a field and seed crop sector, a vegetable and fruit sector, and an electric power sector. Each of these sectors is impacted by the CRI initiative. We formulated a spreadsheet version of the 1987 model that took current (assuming year 2002 dollar values as that is the latest year for which deflators were available) estimates of direct impacts, and calculated indirect and induced impacts of the scenarios for agriculture and electrical power. Updated estimates of employment per million dollars of production were utilized, reflecting productivity improvements since the 1987 model was constructed. Price deflators for each sector were estimated. Current values of final demand, direct purchases, and value added were deflated to 1987 dollars, and then indirect and induced impacts were calculated. The format of the model utilized here separated the final demand values from the direct purchases by sector, and the indirect and induced effects were calculated utilizing a (composite) vector of direct requirements for each scenario. The resulting impacts were then re-expressed as $2002, by applying sectorally specific price indices.

A. Agricultural Impacts

Three scenarios for agricultural production were modeled. The goal in the modeling was to produce a level of output in the field crops and vegetables and fruit sector that was equal to (or approximately equal to) the values estimated by G. Green. Both field crop and vegetable and fruit production is absorbed (in part) by various processing sectors. The most significant linkages are with the grain mill, canning & preserving, and beverages sectors. Following the sales distribution in the 1987 Washington model, 2.5% of field crop output was assumed to be absorbed by grain mills, and 2.3% sold to the beverages sector. Within the 1987 Washington model a substantial fraction of field crop output is sold to the livestock sector. However, the

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[31] **Robert A. Chase, Philip J. Bourque, and Richard S. Conway, Jr.** Washington State Input-Output 1987 Study**. State of Washington Office of Financial Management Forecasting Division.**

agriculture scenarios assumed that there would be no induced development of livestock. Therefore we did not consider the final demand consequences of absorptions of field crops by the livestock sector, and instead sent this output to final demand. Thus, 95.2% of the output of the field crop sector was assumed to be final demand. Within the vegetable and fruit sector, the 1987 Washington model has 36% of the output being absorbed by the canning and preserving sector. We modified this percentage slightly, sending 34% to canning and preserving, 2% of beverages (wine production), and treated the remaining 64% of output as final demand.

The absorption of field crops and vegetables and fruits by the food products processing sector means that a part of the output from the CRI initiative would be a derived demand from these processing sectors. Thus, we needed to have levels of final demand within the processing sectors that would produce (directly and indirectly) the levels of demand for the agricultural sectors found in the three agriculture scenarios. These demands would be the combination of agricultural output sold directly to final demand, and agricultural output demanded in the processing sectors. We utilized the 1997 benchmark national input-output table to determine the share of field crop input per dollar of output in grain milling, because Washington grain mills utilize a large share of grains imported from other states. If we utilized the absorption coefficient in the 1987 Washington model we would have overstated dramatically the value of output in grain mills associated with Washington field crop output being absorbed by Washington grain mills. This national coefficient is .467; thus estimated sales to grain mills in the various scenarios were divided by this coefficient to obtain a first approximation of grain mill output. We utilized the 1987 Washington model coefficients for the absorption of vegetables and fruit (.187), and relied on the national input-output model wine sector to estimate the relationship between beverage (wine) output and the purchase from the vegetables and fruit (grapes) sector (.138). It should be noted that the wine industry in Washington State has blossomed significantly since the 1987 Washington input-output table was constructed. Our estimate of the share of the output in the vegetables and fruit sector absorbed by beverages vs. canning and preserving should be regarded as provisional.

Table 9.1 contains the initial allocations of output in the various agricultural and food products processing sectors. The total values for field crops and vegetables and fruits in this table differ from the output figures in the agricultural scenarios, as the input-output multipliers pick up the derived demands for the agricultural output estimated to be absorbed by the food products processing sectors.

Table 9.1 Initial Allocations of Output by Scenario (current $ in millions)

Scenario 1	Grain Mills	Canning & Preserving	Beverages	Final Demand
Field Crops	0.507	0.000	0.466	19.299
Vegetables & Fruit	0.000	158.333	9.314	298.038
Canning	0.000	845.059	0.000	845.059
Grain Mills	1.110	0.000	0.000	1.110
Beverages	0.000	0.000	67.260	67.260
Scenario 2	Grain Mills	Canning & Preserving	Beverages	Final Demand
Field Crops	0.321	0.000	0.296	12.236
Vegetables & Fruit	0.000	110.993	6.529	208.928
Canning	0.000	0.000	0.000	592.394
Grain Mills	0.000	0.000	0.000	0.704
Beverages	0.000	0.000	0.000	47.150
Scenario 3	Grain Mills	Canning & Preserving	Beverages	Final Demand
Field Crops	0.106	0.000	0.098	4.051
Vegetables & Fruit	0.000	56.129	3.302	105.655
Canning	0.000	0.000	0.000	299.575
Grain Mills	0.000	0.000	0.000	0.233
Beverages	0.000	0.000	0.000	23.844

Table 9.2 contains the direct impact values used to drive the input-output model, which along with the direct requirements estimates contained in Table 9.3 yield the economic impact estimates presented below. Table 9.2 indicates output figures that are the same as in Table 9.1 except for field and seed crops. Because of the complex patterns of interdependence captured in the input-output inverse matrix output estimates in this sector exceeded the production levels forecast in the various agricultural scenarios. In order to control for this effect, final demand in

field crops was reduced to a level that resulted in an output effect that was approximately equal to the production levels in the agricultural scenarios.

Table 9.2 Scenario 1 Direct Impact Values.

	Output		Value Added
	Mils. $2002	Employment	Mils. $2002
1 Field & Seed Crops	12.299	188	6.804
2 Vegetables & Fruit	298.038	6,864	222.216
10 Canning & Preserving	845.059	5,052	300.243
11 Grain Mill	1.110	2	0.264
12 Beverages	67.260	141	30.129
Total	$1223.766	12,247	$559.656

The direct requirements estimates contained in Table 9.3 cover the three agricultural scenarios. These were derived by multiplying the output estimates in Table 9.2 by the direct requirements coefficients for these sectors in the 1987 Washington input-output model. The values for the individual sectors were combined to produce the direct requirements estimates contained in Table 9.3.

Table 9.3 Direct Requirements Estimates

Direct Requirements	Scenario 1	Scenario 2	Scenario 3
		($ million 2002)	
1 Field & Seed Crops	$2.964	$1.777	$0.787
2 Vegetables & Fruit	160.905	112.796	57.041
3 Livestock	5.409	3.747	1.879
4 Other Agriculture	1.443	1.012	0.512
5 Forestry	0.000	0.000	0.000
6 Fisheries	38.741	27.158	13.734
7 Mining	0.594	0.409	0.204
8 Meat Products	1.859	1.303	0.658
9 Dairy Products	2.527	1.771	0.896
10 Canning & Preserving	14.808	10.380	5.249
11 Grain Mill	1.684	1.181	0.597
12 Beverages	1.252	0.871	0.438
13 Other Foods	6.542	4.586	2.319
14 Textiles	0.000	0.000	0.000
15 Apparel	0.284	0.199	0.101
16 Logging	0.000	0.000	0.000
17 Sawmills	0.000	0.000	0.000
18 Plywood	0.000	0.000	0.000
19 Other Wood	3.966	2.780	1.406
20 Furniture	0.000	0.000	0.000
21 Pulp Mills	0.000	0.000	0.000
22 Paper Mills	0.010	0.006	0.002
23 Paperboard	20.915	14.661	7.413
24 Printing	4.502	3.156	1.596
25 Industrial chemicals	7.269	4.818	2.338
26 Other Chemicals	0.042	0.029	0.015
27 Petroleum	9.541	6.487	3.208
28 Glass Products	13.756	9.643	4.877
29 Cement & Stone	0.000	0.000	0.000
30 Aluminum	0.000	0.000	0.000
31 Other Primary Metals	0.000	0.000	0.000
32 Structural Metals	0.000	0.000	0.000
33 Fabricated Metals	17.052	11.946	6.037
34 Industrial Machinery	0.479	0.336	0.169
35 Computer Equip	0.000	0.000	0.000
36 Electric Machinery	0.000	0.000	0.000
37 Aerospace	0.000	0.000	0.000
38 Motor Vehicles	0.234	0.162	0.081
39 Ship & Boat Bldg	0.000	0.000	0.000
40 Instruments	0.421	0.295	0.149

Table 9.3, continued			
41 Other Manufacture	4.958	3.476	1.758
42 Hwy Construction	0.000	0.000	0.000
43 Other Construction	3.655	2.520	1.260
44 Railroad Transport	2.469	1.709	0.856
45 Local Transport	0.938	0.655	0.330
46 Trucking	18.101	12.647	6.380
47 US Post Service	0.386	0.271	0.137
48 Water Transport	1.530	1.061	0.532
49 Air Transport	0.913	0.640	0.324
50 Pipeline	0.000	0.000	0.000
51 Transport Services	0.141	0.099	0.050
52 Electric Companies	10.294	7.168	3.607
53 Gas Companies	7.344	5.148	2.604
54 Other Utilities	4.939	3.414	1.710
55 Communications	3.941	2.748	1.384
56 Wholesale Trade	73.434	51.310	25.883
57 Eating & Drinking	0.342	0.240	0.121
58 Other Retail Trade	1.200	0.821	0.408
59 FIRE	3.972	2.742	1.371
60 Business Services	19.913	13.950	7.049
61 Health Services	0.000	0.000	0.000
62 Other Services	6.954	4.798	2.398
Value added	563.529	391.706	196.879

The direct requirements estimates presented in Table 9.3 was multiplied against the direct, indirect, and induced requirements matrix to calculate indirect effects. These impacts were then added to the direct impacts contained in Table 9.2 to obtain the total impacts that are reported in Table 9.4. Output impacts were used to calculate indirect employment and value added impacts, which were added to the direct impacts contained in Table 9.2.

Table 9.4 Scenario 1, Impact Estimates

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$20.398	312	$11.261
2 Vegetables & Fruit	465.754	10726	338.975
3 Livestock	17.250	336	6.200
4 Other Agriculture	3.441	67	2.548
5 Forestry	2.236	16	1.689
6 Fisheries	41.133	299	18.421
7 Mining	3.967	27	1.718
8 Meat Products	12.994	57	1.010
9 Dairy Products	10.937	48	1.519
10 Canning & Preserving	863.638	5163	259.236
11 Grain Mill	6.619	13	1.894
12 Beverages	76.370	160	29.391
13 Other Foods	15.959	70	8.687
14 Textiles	0.542	9	0.462
15 Apparel	1.855	31	0.785
16 Logging	4.311	18	1.130
17 Sawmills	6.922	28	1.941
18 Plywood	0.569	2	0.156
19 Other Wood	7.879	32	2.306
20 Furniture	0.935	8	0.426
21 Pulp Mills	0.184	1	0.047
22 Paper Mills	6.621	29	2.791
23 Paperboard	31.187	135	11.822
24 Printing	22.541	158	10.747
25 Industrial Chemicals	15.374	59	9.236
26 Other Chemicals	1.840	7	0.722
27 Petroleum	39.170	27	6.530
28 Glass Products	15.140	95	7.150
29 Cement & Stone	1.472	9	0.669
30 Aluminum	1.662	3	0.302
31 Other Primary Metals	1.940	4	0.618
32 Structural Metals	0.665	4	0.265
33 Fabricated Metals	20.359	136	7.647
34 Industrial Machinery	1.255	8	0.934
35 Computer Equipment	0.264	2	0.222
36 Electric Machinery	0.613	5	0.366
37 Aerospace	0.169	0	0.044
38 Motor Vehicles	0.743	4	0.404
39 Ship & Boat Bldg	3.619	29	1.108

Table 9.4 , continued	Output Mils. $2002	Employment	Value Added Mils. $2002
40 Instruments	2.803	24	1.626
41 Other Manufacture	8.180	71	3.864
42 Hwy Construction	0.085	0	0.036
43 Other Construction	29.361	160	10.505
44 Railroad Transport	4.596	46	2.067
45 Local Transport	5.165	52	3.620
46 Trucking	31.295	313	16.926
47 US Post Service	4.058	41	3.158
48 Water Transport	3.298	33	1.466
49 Air Transport	5.912	59	2.269
50 Pipeline	0.142	1	0.098
51 Transport Services	0.890	9	0.468
52 Electric Companies	69.671	101	39.339
53 Gas Companies	20.061	29	9.868
54 Other Utilities	19.147	28	9.459
55 Communications	34.935	142	32.317
56 Wholesale Trade	129.436	1610	87.933
57 Eating & Drinking	66.375	826	26.947
58 Other Retail Trade	171.925	2139	100.316
59 FIRE	134.631	894	60.883
60 Business Services	57.575	409	32.504
61 Health Services	150.896	1940	63.062
62 Other Services	147.144	2807	85.202
Total	2826.109	29869	1345.316

Table 9.5 presents results in a more compact form than in Table 9.4, summarizing impacts by broad categories of sectors. The impact estimates indicate multipliers in the range of 2.3 to 2.4 for the three measures included in this table.

Table 9.5 Summary Measures of Impact, Scenario 1.

Output (Mils. $2002)	**$2826.109**
Manufacturing	1185.331
Nonmanufacturing	1640.777
Wholesale and Retail Trade	367.736
Services	490.246
Other	782.795
Employment	**29,869**
Manufacturing	939
Nonmanufacturing	28,931
Wholesale and Retail Trade	4,575
Services	6,050
Other	18,306
Value Added (Mils. $2002)	**$1345.316**
Manufacturing	376.058
Nonmanufacturing	969.258
Wholesale and Retail Trade	215.197
Services	241.651
Other	512.410

Scenarios 2 and 3 were approached in the same manner as scenario 1, and Tables 9.6 through 9.11 present results of calculations for these scenarios. Scenario 2 is a lower level of production than scenario 1, and scenario 3 and even lower level of production than scenario 2. Thus, the magnitude of the impacts as presented in these tables decreases with regard to these scenarios, but not in an exactly proportional manner due to changing crop mixes.

Table 9.6 Scenario 2, Final Demands

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$7.536	115	$4.169
2 Vegetables & Fruit	208.928	4,812	155.775
10 Canning & Preserving	592.394	3,542	210.473
11 Grain Mill	0.704	1	0.167
12 Beverages	47.150	99	21.121
Total Direct	$856.712	8,569	$391.706

Table 9.7 Scenario 2, Direct, Indirect & Induced Impacts

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$12.874	197	$7.157
2 Vegetables & Fruit	326.489	7519	237.616
3 Livestock	12.004	234	4.315
4 Other Agriculture	2.407	47	1.783
5 Forestry	1.564	11	1.181
6 Fisheries	28.829	209	12.911
7 Mining	2.764	19	1.197
8 Meat Products	9.063	40	0.705
9 Dairy Products	7.634	33	1.060
10 Canning & Preserving	605.403	3619	181.721
11 Grain Mill	4.552	9	1.309
12 Beverages	53.498	112	20.586
13 Other Foods	11.147	49	6.068
14 Textiles	0.379	6	0.323
15 Apparel	1.294	21	0.547
16 Logging	3.016	12	0.790
17 Sawmills	4.842	20	1.358
18 Plywood	0.398	2	0.109
19 Other Wood	5.520	23	1.616
20 Furniture	0.651	6	0.297
21 Pulp Mills	0.128	1	0.033
22 Paper Mills	4.626	20	1.950
23 Paperboard	21.844	94	8.280
24 Printing	15.731	110	7.500
25 Industrial Chemicals	10.455	40	6.281
26 Other Chemicals	1.283	5	0.504
27 Petroleum	27.147	19	4.526
28 Glass Products	10.609	67	5.010
29 Cement & Stone	1.025	6	0.466
30 Aluminum	1.163	2	0.211
31 Other Primary Metals	1.356	3	0.432
32 Structural Metals	0.463	3	0.185
33 Fabricated Metals	14.254	95	5.354
34 Industrial Machinery	0.877	5	0.653
35 Computer Equipment	0.184	1	0.155
36 Electric Machinery	0.428	4	0.255
37 Aerospace	0.117	0	0.030
38 Motor Vehicles	0.517	3	0.281
39 Ship & Boat Bldg	2.532	20	0.775
40 Instruments	1.956	17	1.134

Table 9.7, continued			
41 Other Manufacture	5.724	50	2.704
42 Hwy Construction	0.059	0	0.025
43 Other Construction	20.432	111	7.311
44 Railroad Transport	3.193	32	1.436
45 Local Transport	3.600	36	2.524
46 Trucking	21.851	218	11.818
47 US Post Service	2.829	28	2.202
48 Water Transport	2.294	23	1.020
49 Air Transport	4.124	41	1.583
50 Pipeline	0.099	1	0.068
51 Transport Services	0.621	6	0.326
52 Electric Companies	48.562	70	27.420
53 Gas Companies	14.023	20	6.898
54 Other Utilities	13.313	19	6.577
55 Communications	24.350	99	22.525
56 Wholesale Trade	90.377	1124	61.398
57 Eating & Drinking	46.248	575	18.776
58 Other Retail Trade	119.765	1490	69.882
59 FIRE	93.792	623	42.415
60 Business Services	40.207	285	22.699
61 Health Services	105.127	1351	43.935
62 Other Services	102.479	1955	59.339
Total	$1974.094	20,864	$939.545

Table 9.8 Scenario 2, Summary Impacts

Total Impact	Washington
Output (Mils. $2002)	**$1,974.094**
Manufacturing	829.818
Nonmanufacturing	1,144.276
Wholesale and Retail Trade	256.390
Services	341.605
Other	546.281
Employment	**20,864**
Manufacturing	655
Nonmanufacturing	20,208
Wholesale and Retail Trade	3,190
Services	4,215
Other	12,804
Value Added (Mils. $2002)	**$939.545**
Manufacturing	263.209
Nonmanufacturing	676.336
Wholesale and Retail Trade	150.055
Services	168.388
Other	357.893

Table 9.9 Scenario 3 Final Demands

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$1.681	26	$0.930
2 Vegetables & Fruit	105.655	2433	78.776
10 Canning & Preserving	299.575	1791	106.436
11 Grain Mill	0.233	0	0.055
12 Beverages	23.844	50	10.681
Total	$430.99	4300	$196.88

Table 9.10 Scenario 3 Direct, Indirect & Induced Impacts

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	4.255	65	2.544
2 Vegetables & Fruit	165.102	3802	120.160
3 Livestock	6.039	118	2.171
4 Other Agriculture	1.215	24	0.900
5 Forestry	0.789	6	0.596
6 Fisheries	14.577	106	6.528
7 Mining	1.391	9	0.603
8 Meat Products	4.566	20	0.355
9 Dairy Products	3.848	17	0.535
10 Canning & Preserving	306.148	1830	91.895
11 Grain Mill	2.174	4	0.636
12 Beverages	27.040	57	10.404
13 Other Foods	5.623	25	3.061
14 Textiles	0.192	3	0.163
15 Apparel	0.652	11	0.276
16 Logging	1.523	6	0.399
17 Sawmills	2.445	10	0.686
18 Plywood	0.200	1	0.055
19 Other Wood	2.790	11	0.817
20 Furniture	0.328	3	0.149
21 Pulp Mills	0.064	0	0.016
22 Paper Mills	2.332	10	0.983
23 Paperboard	11.039	48	4.184
24 Printing	7.930	56	3.781
25 Industrial Chemicals	5.172	20	3.107
26 Other Chemicals	0.647	2	0.254
27 Petroleum	13.616	9	2.270
28 Glass Products	5.363	34	2.533
29 Cement & Stone	0.516	3	0.234
30 Aluminum	0.588	1	0.107
31 Other Primary Metals	0.685	1	0.218
32 Structural Metals	0.233	2	0.093
33 Fabricated Metals	7.201	48	2.705
34 Industrial Machinery	0.442	3	0.329
Table 10, continued			
35 Computer Equip	0.093	1	0.078
36 Electric Machinery	0.216	2	0.129
37 Aerospace	0.059	0	0.015
38 Motor Vehicles	0.260	1	0.141
39 Ship & Boat Bldg	1.279	10	0.391

Table 9.10, continued			
	Output Mils. $2002	Employment	Value Added Mils. $2002
40 Instruments	0.986	9	0.572
41 Other Manufacture	2.891	25	1.366
42 Hwy Construction	0.030	0	0.013
43 Other Construction	10.278	56	3.677
44 Railroad Transport	1.603	16	0.721
45 Local Transport	1.813	18	1.271
46 Trucking	11.018	110	5.959
47 US Post Service	1.425	14	1.109
48 Water Transport	1.153	12	0.513
49 Air Transport	2.078	21	0.797
50 Pipeline	0.050	0	0.034
51 Transport Services	0.313	3	0.165
52 Electric Companies	24.456	35	13.809
53 Gas Companies	7.077	10	3.481
54 Other Utilities	6.693	10	3.307
55 Communications	12.262	50	11.343
56 Wholesale Trade	45.570	567	30.958
57 Eating & Drinking	23.285	290	9.453
58 Other Retail Trade	60.290	750	35.179
59 FIRE	47.216	314	21.352
60 Business Services	20.274	144	11.446
61 Health Services	52.925	680	22.118
62 Other Services	51.579	984	29.866
Total	$993.898	10496	$473.011

Table 9.11 Scenario 3, Summary Impacts

Total Impact	Washington
Output (Mils. $2002)	**$993.898**
Manufacturing	419.139
Nonmanufacturing	574.759
Wholesale and Retail Trade	129.145
Services	171.995
Other	273.619
Employment	**10496**
Manufacturing	330
Nonmanufacturing	10166
Wholesale and Retail Trade	1607
Services	2122
Other	6438
Value Added (Mils. $2002)	$473.011
Manufacturing	132.937
Nonmanufacturing	340.074
Wholesale and Retail Trade	75.590
Services	84.783
Other	179.701

B. Electrical Power

Section 5 presents estimates of losses of hydropower output, presumed to be losses in export sales due to the various scenarios. These scenarios are based on an average value per MWH of about $32. In 1987 (the year against which the input-output model is benchmarked), export sales value for hydropower was approximately $17 per MWH. Estimates for total losses in hydropower represent about 1% of exports in 1987, and about 0.1% of total production in that year. Clearly, these impacts are small in magnitude compared to the direct impacts of added agricultural production.

In estimating the impacts of lost power production, the electrical industry direct requirements coefficients in the i/o matrix was modified to estimate direct purchase requirements. The 1987 model has a rather sizeable transaction within the electrical power production sector, representing wholesale sales from generators such as Bonneville to retail utilities in the region (such as City Light). There would not be this intraindustry transaction in the scenario being modeled here. Value added was increased by 90% of the magnitude of this intraindustry coefficient, and the intraindustry direct requirements coefficient was set at 10% of the value in the 1987 input-output model.

Tables 9.12 and 9.13 present summary impact estimates for these small reductions in hydropower exports. These scenarios would lead to job reductions in the 67 to 102 person range, output losses of $12 to $19 million, and reductions in value added of $7 to $11 million. Clearly, the negative impact estimates contained in Table 9.12 and 9.13 are several orders of magnitude smaller than the positive impact estimates reported above in the section on agriculture.

Table 9.12 Maximum Loss of Hydropower ($9.7 million)

Total Impact	Washington
Output (Mils. $2002)	**-18.745**
Manufacturing	-0.936
Nonmanufacturing	-17.808
Wholesale and Retail Trade	-2.321
Services	-3.833
Other	-11.654
Employment	**-102**
Manufacturing	-3
Nonmanufacturing	-99
Wholesale and Retail Trade	-29
Services	-48
Other	-22
Value Added (Mils. $2002)	**-11.320**
Manufacturing	-0.327
Nonmanufacturing	-10.994
Wholesale and Retail Trade	-1.292
Services	-1.870
Other	-7.832

Table 9.13 Impacts of Minimum Loss of Hydropower ($6.4 million)

Total Impact	Washington
Output (Mils. $2002)	**-12.289**
Manufacturing	-0.614
Nonmanufacturing	-11.675
Wholesale and Retail Trade	-1.522
Services	-2.513
Other	-7.640
Employment	**-67**
Manufacturing	-2
Nonmanufacturing	-65
Wholesale and Retail Trade	-19
Services	-31
Other	-14
Value Added (Mils. $2002)	**-7.421**
Manufacturing	-0.214
Nonmanufacturing	-7.207
Wholesale and Retail Trade	-0.847
Services	-1.226
Other	-5.135

10. PASSIVE USE VALUES ASSOCIATED WITH CRI SCENARIOS

In addition to economic values associated with recreational and commercial fishing, economists define and occasionally measure values associated with the simple presence of a fish population. The value is reckoned as the amount that people (defined appropriately) would be willing to pay to assure the existence of something even if they do not directly use it. The something could be a fish stock, and the passive use value would be the public's willingness to pay for a specified increase in the fish stock. These values are separate and additional to values for harvesting fish. Hence the term "passive use" value. These values are also sometimes called "existence values" or "non-use values". In theory, passive use values could exist for any conceivable product, resource, or condition. For example, some people might place value on the continued existence of dams, fish hatcheries, or farming as a way of life. While the measurement and use of passive use values in natural resources damage assessment and benefit cost analysis continues to provoke controversy (see Diamond and Hausman 1994), many environmental economists have come to terms with the difficulties of measurement (Hanneman, Loomis and Kanninen, 1991; Layton, Brown and Plummer 1999; Loomis 1996a; Loomis 1996b; Loomis 1999; McFadden 1994; Olsen, Richards, and Scott 1991).

The most frequent focus for passive use value estimation is the value of public goods or environmental conditions that people experience. For example, people place value on saving whales, endangered species, ancient trees, and pristine ecosystems. Of more direct interest here, Olsen, Richards and Scott (1991) found that people who claimed no intention to catch or eat salmon from the Columbia river were still willing to pay on average $26.52 per year per household ($35.12 in 2002$) to obtain a doubling of the salmon run size. These passive use values are non-exclusive, meaning that everyone who values the fish run obtains this value simultaneously (as contrasted with consumptive use values which accrue only to those catching fish in competition with others). Hence, assuming (1) that all households enjoy this non-use value, (2) that a doubling of the fish run means 2.5 million fish per year, and (3) that there are roughly 2.0 million households in the relevant region[*], that value of doubling the run would be $70.24 million/year.

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[*] Olsen, et al. take this as roughly the number of households in the Washington, Oregon, Idaho region in 1989.

More recently, the US Army Corps of Engineers Study of Snake R Salmon Migration (1999) uses an amalgam of previous estimates to show that a reduction of 428 in Snake R salmon run causes a reduction of $97,360 in passive use value--equivalent to $66.28 per fish.

A. Total Economic Values

Some studies of economic value do not attempt to divide values into use value and non-use (or passive use) values (Randall and Stoll 1983; Sanders, Walsh, and Loomis. 1990). Instead, they aim directly to estimate the total value of a change in an environmental condition or animal population. Recently, Layton, Brown and Plummer (1999) have estimated an individual value function for a variety of fish categories (including Columbia basin migratory fish) among Washington residents. Completed for the Washington Department of Ecology, that study developed a means of estimating willingness to pay for any given increase in fish population from an assumed current level, and for two different “baseline” fish population projections. For example, for a current fish population of 2 million and a projected stable future population of 2 million in the Columbia basin, Layton, et al. find that the typical Washington household would be WTP $119.04 per year for a 50% increase in the migratory fish population. This represents the total (use plus non-use) value for the fish population increase. With a total of 2 million households holding such values, the overall value per fish is a remarkable $268.08. This particular estimate pertains to a rather broad class of fish, including all the salmon and steelhead stocks in the Columbia basin. There are apparently no studies that specifically focus on the salmon stocks most likely to be affected by additional Columbia River mainstem water diversions in Washington State.

B Role of Passive Use value in Water Policy Decisions

As a matter of principle, any economic assessment of water policy should give equal consideration to passive use value and recreational/commercial use values. That this is rarely done is largely due to two underlying factors: (1) the credibility of passive use value estimates is often called into question, and (2) the methods for accurately estimating passive use values (contingent valuation being the predominant method) are costly and demanding. The credibility issue is partly due to the public disbelief in measures of value that are not routinely and commonly understood – such as market prices and personal income – and partly due to the lack on consensus in the economics profession concerning adequate measurement standards (Hausman and Diamond). While the burden of estimating passive use values may be accepted in extreme cases, such as in the multi-million dollar lawsuits over the Exxon Valdez oil spill in 1989, for routine decision making over water rights and river operations, the time delay and cost of undertaking passive use values (involving sampling of public opinion via surveys or polls) generally excludes their use. However, general valuation models, such as that developed by Layton, Brown and Plummer (1999), may offer the promise of low-cost inclusion of passive use values and recreational values in agency decision processes.

Finally, the use of passive use value estimates for salmon and other fish species, when there are no comparable estimates of other passive use values, may bias decisions involving numerous changes to resources and communities. There is generally some uncertainty concerning the magnitudes of various passive use values that may be relevant to an economic assessment. Hence, a judgment call must be made regarding the inclusion of passive use values for some policy consequences and not for others. It may be judged that passive use values are more significant for public resources and environmental conditions than for marketed commodities and production equipment, in part because they have no comparable market prices or income-related measures of economic value. Since salmon and other migratory fish species have market prices and recreational values, some may find that passive use values are superfluous. Others (Loomis 1996a and 1996b), focusing on the unique and endangered character of the salmon populations, may conclude that passive use values are widely held by the public and are an essential feature of a full economic assessment of water policies.

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CHAPTER 11. WATER MARKETS: PROMISE AND PROSPECTS

Water scarcity is a growing problem in Washington State as regional economies have developed and society has become more concerned with the environmental benefits of maintaining instream water flow. Historically water scarcity was alleviated by building large water storage projects to capture water during periods with high flow to be used during periods with low water flow. The expense and environmental concern associated with storage projects have turned attention to other means of coping with water scarcity. One approach is to encourage the transfer of water from low to high value uses, thereby increasing the benefit derived from available water resources and encouraging water conservation. In many river basins there is little incentive, and few institutionalized mechanisms for water transfers by water rights holders. However, this is changing as many States in the arid West have developed some forms of water marketing institutions.

In the western United States most individuals and groups that divert water for out-of-stream uses have been allocated water by State governments based on the prior appropriations doctrine. The prior appropriations doctrine can generally be characterized by two criteria, “first in time, first in right,” and “beneficial use.” First in time, first in right indicates that existing and future rights to water resources are based on the historical pattern of water use. Individuals who have been using water the longest (the “senior rights holders”) have the highest priority for receiving water supplies. Since many rivers are fully appropriated, new water users are not able to secure reliable water rights regardless of the value of its use; thereby limiting the benefit derived from scarce water resources. The beneficial use clause of the doctrine calls for the forfeiture of a water right that is not put to beneficial use; and is often referred to as the “use it or lose it clause.” Water users that admit they have excess water to transfer often fear they may lose their right to that water if they put it up for transfer. During the last several decades a number of states have enacted legislation to recognize water transfers as a beneficial use. This allows water right holders to transfer their water rights without fear of losing them.

Historically, drought and water supply variability have been the primary factors that lead to competition for water resources. Under prior appropriations, water users with a low priority right are left short of water when supplies are, low regardless of use. Water transfers have been proposed as a way to reduce the allocative inefficiencies of the prior appropriations doctrine (Burness and Quirk, 1979; Howe et al., 1986; and Colby, 1990). Water transfers have received the most attention during drought periods to move water within agriculture (Dinar and Letey, 1991) or to urban uses (Taylor and Young, 1995; Michelsen and Young, 1993). However, more recent attention has been given to transferring water for environmental uses (Fadali and Shaw, 1998; Weinberg et al., 1993). Most water transfer studies have focused on the implementation of water markets; however, water banking and leasing programs are more common in practice (Howitt, 1991; MacDonnell et al., 1994, p. 1-3).

Water markets, leases, and banks are often promoted in the hope they will encourage more efficient water use. The idea of free market transactions — willing-seller/willing-buyer — is that water will flow to those who can make the most productive use of it. A water user will weigh their value of using the water against what another water user would be willing to pay for that water. In this sense, the use value of their water is the opportunity cost of transferring that water to another water user. This encourages water to move from low to high value uses, thereby increasing the benefit derived from limited water resources. This also encourages water users to conserve water if they are allowed to sell their reduction in water use. However, it is critical that reductions in water use by one user do impact the water supply of other users through hydrologic linkages within the river basin (Green and Hamilton, 2000). More specifically, water conservation must be defined in terms of reductions in consumptive use, not diversions, to insure other water users are not affected by conservation measures. This issue will be discussed in more detail in section 11.A.

The primary water transfer mechanisms include: water markets, which generally facilitate the permanent transfer of water rights; water leases, which facilitate the temporary transfer of flow water rights; and water banks, which facilitate the temporary transfer of storable water. There are also a number of variations on these, such as split season transfers, contingent transfers, and direct trading of commodities like hay for water. Water banking and leasing may be more attractive to many water right holders since they are able to maintain control over future use of the water and opportunities that may arise from having that right. The temporary aspect of these institutions helps traders to become accustom to water transfers without making an irreversible decision regarding their water right, which removes the all-or-nothing nature of a permanent transfer.

Water transfer institutions serve as intermediaries that help to reduce the cost of transferring water between users. These costs fall within two categories; the cost of physically transferring water and the implicit cost of matching willing sellers and willing buyers. A water bank works to reduce these costs by acting as a broker to bring buyers and sellers together in an institution with publicly known procedures. It determines the parameters of the trade, including the portion of the water that may be transferred. Water transfer policies have been used for many years in various forms; however, their primary intent has been to move water within a given system. Using water banks as a mechanism to transfer water between water systems and to emerging water users marks an important change in the role of transfers for reallocating water.

Water transfers are not a new idea and have been occurring in Washington State for many years. However, these transfers have historically been between agricultural users. Trading between different types of water users is relatively new and is where water transfer institutions can help the most as intermediaries. These types of trades include transferring water from agriculture to municipal, industrial and environmental uses. Most water transfers involve agricultural water users since they have approximately 85-percent of the water rights in Washington.

Water transfers have worked effectively in many regions of the Western United States. Below we will discuss several of the issues that must be addressed when developing water transfer institutions. We will review a number of the water transfers that have already taken place in Washington. We finish by looking at the potential for water transfers in the Columbia River Basin.

A. Issues in Water Marketing

Unfortunately instituting water transfers face several hurdles, both physical and social. First, water users are not independent of each other. It is common that not all diverted water will be consumptively used and a portion of the water that is not consumptively used will become return flow that supplies other water users. As a result, water transfers may impact individuals that are not involved in the exchange, making it necessary to distinguish between consumptive and non-consumptive use. Second, local communities often depend on the tax base and employment generated by agricultural and industrial water use. If a large portion of a region’s water rights are transferred to another region or use that does not generate the same tax base the community could be lose its primary source of funding. Finally, to many individuals the idea of transferring water between uses is new. The perception of significant changes in water allocation may be met with skepticism and distrust, which could hinder the implementation of water transfer policy. Each of these issues can make designing and implementing water transfer policy a difficult task.

A key factor in designing water transfer policy is that water users are not independent of one another. Water users generally divert more water than is consumptively used. The excess diversions are then either lost or return to the system. The excess diversions that return to the system are called return flow and act as a water supply to other water users. As a result, it is important that water users are only allowed to transfer the consumptively used portion of their water right. Otherwise, they could be transferring water that is usually used by another water user. For example, suppose a water user usually diverts 100 acre-feet, consumes 50 acre-feet, 30 acre-feet become return flow, and the remaining 20 acre-feet are lost through evaporation and other irretrievable losses. In this case, the water user would only be able to transfer 70 acre-feet to another water user. The 30 acre-feet of return flow would need to remain protected instream until the point where it had provided water supply to the hydrologic system.

Defining the consumptively used portion of a water right is a technical issue that has important ramifications for whether a transfer policy will work effectively or not. The agency in charge of regulating water transfers sets a procedure for calculating the consumptively used portion and this is used in the transaction. Most states allow only the consumptively used portion of a water right to be transferred between water users.

Conserved water is often cited as a source for water transfers, where conserved water may arise from changes in irrigation technologies, cropping patterns or improvements in distribution systems. Instituting water transfer policy may encourage water users to use their water more efficiently if they are able to sell the conserved water. However, third party impacts are likely to arise if conservation projects reduce diversions without reducing consumptive use and the reduction in diversions are then transferred. Returning to the example sited above, suppose the water user invests in a new production technology such that only 70 acre-feet are diverted (rather than 100); 50 acre-feet are still used consumptively, 15 acre-feet become return flow (rather than 30 acre-feet), and 10 acre-feet are lost (rather than 20). Even though diversions are reduced by 30 acre-feet, there is only a 10 acre-foot reduction in losses. In such a case, the water user could only transfer 10 acre-feet. The remaining 20 acre-feet would consist of 15 acre-feet that would remain instream until the point where it was deemed to be a supply to other users under the original use pattern and 5 acre-feet would still be considered an irretrievable loss. In this example, the water user paid to reduce diversions by 30 acre-feet, but could only transfer 10 acre-feet. As a result, the opportunity to transfer conserved water may not be as strong as one would think at first glance. As a side note, it should be recognized that the 15 acre-feet that are left instream before replacing reduced return flow could provide benefit to instream uses like habitat restoration or hydropower production. Though early attempts at water transfer policy did not recognize the importance of defining consumptive use, it has been recognized in existing case law (Benningfield v. DOE, PCHB No. 87-106, 1987).

A number of established economies depend on the income generated by agricultural and industrial production that depends on the existing water rights allocation. The communities depend directly via employment, sales and taxes, and indirectly through multiplier effects. Transferring water rights to different uses in different regions could reduce the regional employment and tax base, leaving the community with out the ability to continue providing quality education, police and fire protection, and other publicly provided services. While the willing seller is just as well or better off, the remaining community is impacted through no action of their own. Portions of Western Washington have experienced this with the large reduction in the timber industry in the late 1980's. As less timber was harvested, fewer raw logs were milled, and the level of unemployment increased dramatically. This spilled over into the local business community as there was a much lower demand for goods and services.

How much of an issue this is depends on the amount of water that is traded from the region. The example of timber communities above was quite severe; however, it was being driven by a dramatic change in technology. For water transfers to cause a similar impact it would be necessary for enormous amounts of water to leave the region. There were similar fears in California's San Joaquin Valley during the drought of the early 1990's. The California drought water bank established a mechanism to transfer water from agriculture to municipal water use in Los Angeles. There was great concern the water demand in Los Angeles would devastate small communities in San Joaquin Valley. It turned out that more water right holders were willing to sell their water then there was demand for water in Los Angeles in spite of the relatively low amount that was placed in the water bank. While the level of municipal and industrial water demand in Eastern Washington is not likely to drive any significant amount of water transfers, there is concern that environmental demand could be significant. However, it is likely that the environmental demand will be wide spread, pulling water from many areas rather than concentrating on any one specific area. This would result in a reduction of low value agriculture while leaving high value agriculture along the Columbia River in tact. To what degree this would impact the surrounding communities depends on the level of demand and what restrictions are placed on the quantity of transfers.

The final issue with regard to water transfer policy relates to how individuals and groups perceive the affects of water transfer. Perception of significant changes in current law may be met with anxiety and skepticism, especially by current water rights holders. In particular, current water law assures security of access to senior rights holders, and any perceived threat to security will be resisted. Water is perceived to belong as much to the historic user class (agriculture, hydropower, etc.) as to the putative property rights holder. That is, water used in agriculture may be perceived to "belong" to agriculture, or even to a particular farm use, rather than to the individual holder of the property right. This ideology is enshrined in the beneficial use aspect of the appropriation doctrine which assigns a water right for a particular use, at a particular location, in perpetuity. The idea of transferring water may therefore be seen by some as more than the movement of property from one owner to another; it may be seen as a change in the moral order. As a result, water users that transfer water to other types of water users may be vilified by others in the community and reduce the incentive to participate in water transfer programs. Examples of this include the Methow River basin in Washington and the Kalamath River basin in California.

B. Water Marketing in the Washington

Despite the complications of implementing water transfer policy discussed above, there are examples of water transfers in Washington State. Washington State water law allows voluntary transfers between willing buyers and sellers provided that third parties are not injured as a consequence of the transfer. Water can be transferred between agricultural, environmental, industrial and municipal uses.[32] Any proposed transfer in place or manner of use of an existing water right must be approved by DOE[33] and a formal application for change of water right must

[32] RCW 90.14.03(2) and RCW 90.54.020(1).

[33] RCW 90.03.390.

be submitted providing detailed information about the present and proposed water uses and the existing water right certificate. The application must be published for public review to allow third parties that may be impacted by the transfer to interject.[34] The formal transfer procedures can be avoided for temporary changes in point of diversion of place of use, but not manner of use

There have long been water transfers with irrigation districts for agricultural use. These transfers often occurred during drought periods when some growers had excess water while others were water short. There have also been transfers from agriculture to municipal and for habitat restoration. For example, in the Yakima River basin a program has been enacted by the United States Congress to encourage conservation and water acquisition for environmental uses. The DOE has also established a water acquisition program to acquire water to augment instream flow for restoration of salmon habitat. The Washington Water Trust, a private non-profit group, operates to purchase and lease water to increase instream flow. These examples indicate that water transfers in Washington are becoming more common and many of the initial hurdles are being overcome.

a. Water Transfers within Irrigation Districts

Three irrigation districts, the Wenatchee, the Yakima-Tieton and the East Columbia, were identified as areas in Washington where water transfers are relatively commonplace. The Wenatchee Irrigation District has been facilitating water transfers for over sixty years. The major restriction on transfers is that all water transfers must be upstream in order to minimize negative third-party impacts. The district representative reports that they have had no third party complaints about transfers; however, parties do get annoyed when the district blocks downstream transfers. Farmers negotiate sales of permanent rights (shares) themselves, including setting their own prices. The district management is interested in the final allocation of shares in order to complete its share assessment billing, and to deliver water to the correct location. All transfers must be within the district’s service area.

The physical distribution system in the Yakima-Tieton Irrigation District is unique in that water is delivered to diversion points in pressurized, underground pipes. Because of this, the

[34] RCW 90.03.280.

district avoids controversies over return flows from conveyance losses. Water is transferred through exchange of shares that vary from year-to-year, depending on water availability for a given year. Water transfers are supposed to be permanent; leasing of water is not a sanctioned activity. Transfers must remain in the district. There are no constraints on the direction (upstream or downstream) of transfer, but farmers cannot hold more than 1.5 shares per irrigable acre. The selling of small fractions of shares is said to be quite common, for example, when people go on a municipally supplied domestic water system.

The East Columbia Irrigation District has a water bank that allows irrigators who hold an early and late service water contract to “buy” additional water for the June-July period. Price for this additional water is the per acre-foot operation and maintenance assessment cost of the banked water, plus an administrative fee, plus a peaking water charge. Irrigators “depositing” water into the bank avoid payment of their operation and maintenance charge, but make no additional profit on the water transfer. These are just several examples found, further investigation would likely turn up more.

b. Water Transfers for Environmental Purposes

The Washington Water Acquisition Program was designed specifically to encourage water conservation for transfer to environmental uses. The state has targeted 16 watersheds in the region with vulnerable salmon and trout populations. The program is a voluntary initiative offering monetary compensation to water right holders and is focused on increasing stream flows in the basins experiencing chronic water shortages, and therefore “at risk” fish populations. The program is designed to allow for participants to contribute to salmon recovery efforts by transferring their rights. State agencies involved in the program include the departments of Ecology, Fish and Wildlife, and Washington Conservation Commission. Ecology has $5.5 million in state and federal funds to acquire water rights.

Program sponsors are offering a variety of ways for farmers, ranchers, and other right holders to participate including selling, leasing, or donating all or part of a water right. Priority will be given first and foremost to right holders that wish to permanently transfer their right to the state water trust. Compensation will be negotiated by the involved parties by determining the fair market price of the right into perpetuity. Long-term leases will be given the next highest priority, followed by short term leases. The program will allow for different types of leasing, such as “split-season” or “dry-year” leases. Again, program sponsors will work with right holders to determine a fair market price for the specified terms of the lease. Leasing might be a particularly attractive option to right holders who are reluctant to make a permanent transfer of their right in that there is no risk of relinquishing the water placed in the program. Another option for participation in the program is for a right holder to donate all or some of a water right. This donation may be a tax-deductible charity, and the donated amount will be returned at the end of the donation period. A final and less direct way that one could participate in the program is through the state Water Irrigation Efficiencies Program. Users may voluntarily place all or part of the water saved into trust. Under specific conditions of the program, a mechanism exists to determine the portion of a block of conserved water that can be transferred to other beneficial uses (Washington State Department of Ecology, 1992).

DOE will determine and negotiate the fair market value of each water transfer proposal using various valuation methods. The right will be priced based on the character of the right, its value to fish, the type on transaction, and the length on transaction. In many cases, the price is determined by an independent water right appraiser. Although the department evaluates each acquisition proposal on a case by case basis, DOE will generally only pay for consumptive use of the water.

Another example includes the Yakima River Basin Water Projects. In 1994, the United States Congress enacted Title XII of Public Law 103-434, the Yakima River Basin Water Enhancement Project (YRBWEP). This authorized the YRBWEP to protect, mitigate, and enhance fish and wildlife and to improve reliability of the water supply for irrigation through improved water conservation and management. More specifically, Sections 1203 and 1205 authorize the purchase or lease of land, water or water rights from anyone willing to limit or forego water use on a temporary or permanent basis to secure instream flows for the benefit of anadromous fish. The United States Bureau of Reclamation (BOR) has been charged with implementing the YRBWEP.

In 1995, BOR started a pilot program investigating the legal and institutional aspects of acquiring water and transferring it to environmental uses. In 1996, BOR continued the pilot program and executed three irrigation water lease contracts for a total of 9 cubic feet per second (cfs) on the Teanaway River, a tributary of the Yakima. The cost of the 9 cfs ranged from $23 to $40 per acre-foot. In 1997, BOR implemented the water acquisition program authorized under the YRBWEP and executed four water lease contracts for approximately 20 cfs, primarily on the Teanaway River. Price ranged from $23 to $35 per acre-foot.

The Teanaway was chosen because: it historically was a large producer of spring chinook, coho and steelhead; it is periodically dewatered for irrigation; and it is an "usual and accustomed fishing site" for the Yakima Indian Nation. The dominate crop in the area is Timothy hay. The land associated with the water leases were fallowed during the term of the lease. In addition to leasing and acquiring water rights, a long-term goal of the YRBWEP is to install water conservation systems to help increase instream flows and the reliability of irrigation water. Smaller tributaries such as the Teanaway are generally targeted for water transfer programs since modest water purchases can make a significant improvement in fish survival rates.

Within the Yakima Basin there is also an effort being made to establish a water bank. DOE has initiated an effort to define the elements of a Yakima Basin water bank, reach basic understanding and acceptance of water banking as a tool and to determine what type of water banking has a good chance of success in the Yakima region. As a fundamental part of this effort DOE will involve Yakima water bank stakeholders in exploring the boundaries and opportunities that a water bank will face. Involving stakeholders is necessary to make sure the bank is active once it is institutionalize.

The Washington Water Trust (WWT) was established in 1998 to restore instream flows in Washington's rivers and streams. The private, non-profit organization uses market based tools by acquiring existing water rights from willing sellers through purchase, lease, or gift, with the intent to improve water quality, fisheries and recreation in the state's rivers and streams. The organization works cooperatively with farmers, ranchers, irrigation districts, tribes, public agencies, land trusts, and other governmental and non-governmental agencies. WWT's focus is on small streams and tributaries where returning a small amount of water could yield significant restoration benefits. The WWT views its market based solution as mutually beneficial to salmon, water quality and the agricultural community. WWT sees water marketing as a restoration strategy that will ease water use conflicts by compensating the agricultural community in voluntary exchange for a water right to be left instream to benefit salmon restoration. A couple of examples of WWT projects include Salmon Creek and Big Valley Ranch.

For many years the lower 4.3 stream miles of the Salmon Creek has been dry except during spring runoff. During the irrigation season, the entire stream flow has been diverted by the diversion dam, discouraging fish migration. Through the creation of a Salmon Creek Trust Water Right water was left instream in 2000, allowing for higher flows, smolt migration, and improved fall and winter conditions. A water bank was established by the Okanagon Irrigation District (OID) in order to increase instream flows. 42 irrigators accounting for 330 acres of land signed up to participate, with the entire amount of water accumulated in the bank left instream, accounting for 990 AF. The Bonneville Power Administration provided funds for the lease. The project has persisted and grown, allowing for approximately 1716 and 1869 AF in 2001 and 2002 respectively. Prices paid for the water were based on assessments and were $135 per acre in 2000, $145 in 2001, and $175 in 2002. The Salmon Creek project has led to some issues that need to be worked out. The temporary nature of the leases has caused some inconsistency in implementation. The three years that the program has been in effect have been drought years in the Okanogan. There has also been some controversy over the project's impact on water levels in Conconully Lake (Salmon Lake). The program is not yet a permanent institution and there will be no leases in 2003. This has caused problems for some irrigators who had planned on the trust water payments. OID and WWT are discussing changes, including depositing future leases in the trust water rights program for the duration of the lease, to provide sustainability of the project and for protection for OID.

c. Water Transfers for Municipal Use

The publication "The Water Strategist" summarizes exchanges of water rights throughout the west for different purposes. Limited records exist of water purchases for M&I uses in Washington. For example, two purchases in Washington were for M&I uses during 2001 where the City of Warden purchased 2,388 AF of Grande Ronde Aquifer GW from an irrigator at a price of $452/AF in June. Also, various businesses, farms, and the Church of Latter Day Saints leased up to 2,596.5 AF of Columbia Basin Project water from the Bureau of Reclamation for $39/AF with a minimum lease of $500 in July and August of 2001. There seems to be a large discrepancy in prices for these two purchases. M&I water will play an increasingly important role in water markets as the need for M&I water increases with population increases. Perhaps municipalities could work in coordination with hydropower and fish habitat restoration in that M&I water, although diversionary, is generally a non-consumptive use since return flows are so high.

C. Prospects for Water Markets in the Columbia River

The discussions above indicate there has been a significant amount of water transfer activity in Washington State. There are also examples of water transfers in the Dungeness, Walla Walla, Touchet, Methow, and Columbia River Basins. All of these examples indicate that there is significant promise for a successful water transfer program in the Columbia River Basin. Institutionalizing such a program will provide information for potential buyers and sellers in the market and reduce transactions costs. Based on the emergence of new high value agricultural, environmental, municipal and industrial water uses, there are willing buyers. The existence of low value crops gives evidence that there are likely to be willing sellers. Institutionalizing the transfer process will allow more trading to occur between agricultural users, agricultural and municipal users, and agricultural and environmental uses, increasing the benefit from existing scarce water resources. This will not be without difficulties. Unfortunately the Columbia River Basin has a significant amount of return flow, complicating the water transfers as was discussed above. The institutional structure will need to account for potential impacts between traders, and externalities to non-traders. An institutionalized water transfer program in the Columbia River Basin has promise and potential, but not without caution and complications. *[We hope to have a brief analysis showing potential gains from water transfers in the final version.]*

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CHAPTER 12. DISCUSSION AND CONCLUSIONS

The purpose of this study is to review the economics of water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI has been proposed as a way to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington state. Through the CRI process the state is seeking to develop an integrated state program that will allow access to the river's valuable water resources while at the same time providing support for salmon recovery. The analysis described herein is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the state has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations. The Department of Ecology will use the information generated by both the NAS science review and this economic review to develop a new water resource management program for the mainstem of the Columbia River.

The CRI contemplates 5 different water management scenarios corresponding to different levels of risk to salmon populations. The table below outlines the scenarios considered in the report. In each of the scenarios in which new water is to be made available (scenarios 1 through 3), 220 KAF of the 1 MAF of potential new water is allocated to the Columbia Basin Project (CBP). Scenario 1 serves as an upper bound for the analysis: it allocated the most water to new water rights, and it imposes the lowest costs on recipients of new water rights. The only costs associated with it are that all new right holders and converted (from interruptible to uninterruptible) rights need to conform to water efficiency Best Management Practices (BMPs). In analyzing Scenario 1, we assume that the entire 1 MAF of water rights offered will granted to water users. Given the existing 4.5 MAF of surface water diversionary rights, this amounts to a 22% increase in water diversion rights.

Table 12.1 Elements of the 5 CRI Management Scenarios

Scenario	First Tier of New Water Rights	Second Tier of New Water Rights	Interruptible Rights
1	1MAF no fees, + new rights must meet BMPs & be metered	None	May be converted to non-interruptible, must conform to BMPs & be metered
2	700 kaf initially +$10/af annual fee + meet BMPs & be metered	300 kaf after 80% of users conform to BMPs + $ 10/af annual fee for all new rights	May be converted to non-interruptible, must conform to BMPs & be metered +$10/af annual fee
3	700 kaf initially +$20/af annual fee + meet BMPs & be metered	300 kaf after 80% of users conform to BMPs + $20/af annual fee for all new rights	May be converted to non-interruptible, must conform to BMPs & be metered +$20/af annual fee
4	All new withdrawals must be offset in proportion to consumption through transfers, conservation, and/or new storage. + fee of $30/af annual fee for new rights	none	May be converted to non-interruptible, must conform to BMPs & be metered +$30/af annual fee
5	Based on opinion of fish managers	none	Based on opinion of fish managers

Scenarios 2 and 3 impose additional costs on water users, but are identical in their potential for new water—1 MAF. The costs of metering water, complying with water efficiency standards, and paying fees for new water should encourage water users will curtail water use. Further, allocation of 300 KAF is contingent on the majority of all water users meeting water efficiency BMPS. Hence, it is not certain that the entire 1 MAF of water will be sought or permitted. To provide for a range of possible outcomes, the study team has constructed lower bounds water allocations for Scenarios 2 and 3. For both scenario 2 and 3 the upper bound estimate is equivalent to that of Scenario 1.

For Scenario 2, with a fee of $10/AF, it is assumed that the last 300 KAF of the full 1 MAF will not be actually be permitted, because the majority of users will not adhere to BMPs. Alternatively, the lower bound could reflect the notion that the increased costs associated with the proposed fees reduce the quantity demanded for new water such that there is insufficient demand for available water. So, for the lower bound estimate under Scenario 2 we have a new allocation of 700 KAF of water; an increase in water diverted of 15%. The lower bound for Scenario 3, where the annual fee rises to $20/AF, we assumed that water demand falls to a level equal to the current application pool plus the 220 KAF for CBP. This amounts to a total of 568 KAF, a 12% increase in water rights in the mainstem Columbia river in Washington State.

Under Scenarios 4 and 5 there would be essentially no additional withdrawals. Scenario 4 calls for all new withdrawals to be offset, based upon consumptive use, by mitigating transfers or conservation or new storage. Scenario 5 is a no action scenario in which the existing rules governing the water resources of the Columbia River remain intact.

IRRIGATED AGRICULTURE

A large portion of the benefits of new water rights will be reaped by the agricultural sector. In a county-by-county assessment, we assume that the new water rights for agriculture will go into a crop mix reflecting that counties recent past production. It is unclear whether new water being made available will go into high-value or low-value crops. Examples of crops that have emerged during the last decade include wine grapes, hops, new apple varieties, storage onions, sweet corn for processing, and fresh vegetables. As a general rule, production of crops that are becoming more valuable will increase (and prices will subsequently decline) until the market becomes saturated. There will always be certain crops that are the fad of the day whose value is high and acreage increases to the point that it is no longer high valued.

To summarize the results of this study, Benton County emerges with the lion’s share of increased gross and net revenues to irrigators. However, this is simply driven by the assumptions made in the extrapolation of pending applications for water rights. It is possible that insufficient irrigable land exists in the county to allow for the extrapolation considered in this report. Perhaps irrigators in the county are unable to get that much water into production, in which case the water might go to some other county for production of a different crop mix, allowing for different gross and net revenues.

Before summarizing the values of gross and net revenues for irrigated agriculture, it is important to reiterate the problem associated with crop budgets and net revenues. It is a perennial problem associated with agricultural economics involving the use of full economic (opportunity) costs versus cash or accounting costs. Net revenues frequently yield negative values when using full economic costs as the crop budgets do.

Gross and net revenues for scenario1 are the same as gross revenues for Scenario 2 and Scenario 3 upper bounds. The gross revenue is $485 million and net revenue is $57 million under the assumptions of these scenarios. For the Scenario 2 lower bound, gross and net revenues are $339 million and $37 million, respectively. For Scenario 3 lower bound, gross and net revenues are $169 million and $18 million, respectively.

M&I WATER VALUES

Diversions of water for municipal and industrial (M&I) use occurs, but the amount of water diverted is very small relative to irrigation diversions. Furthermore, M&I water tends to have a very high return flow associated with it. For these reasons, M&I water is generally not considered a consumptive use of water by many researchers.

Exact values of M&I water have been difficult for the study team to determine because few reliable sources exist regarding it. In terms of value, this report has assumed that M&I water is a higher valued use than water used for irrigation. Furthermore, M&I water seems to be a higher priority than water for other uses because to the increasing needs of water for blossoming urban areas in the state. The study team has assumed that in each scenario, and at the low-level assessment and high-level assessment (applicable to scenarios 2 and 3), M&I water will be granted rights ahead of irrigation water. In each scenario this corresponds to a 30% increase in M&I water rights to the Tri-Cities area corresponding to a 30% increase in population over the next couple of decades. The M&I impacts will be the same for each scenario, and therefore will be constant when comparing any two scenarios.

HYDROPOWER COSTS

Because additional withdrawals of water from the Columbia river will reduce flows downstream through the numerous hydroelectric power plants, the economic effects on the hydropower system are all negative; they incur costs. For Management Scenario 1, which adds 1 million acre-feet of new diversions -- 919,248 acre-feet of which is for irrigated agriculture -- the full cost to the hydroelectric power system of new withdrawals (distributed across reservoirs as shown estimated in Table 1.4) varies from $9.4 million/year in average water years to $9.7 million/yr in a dry year. In addition to this lost of hydropower, the new 220 kaf of water proposed for the Columbia Basin Project will cost an estimated $2.465 million in power for pumping water up to Banks Lake.

Hydropower costs associated with Management Scenarios 2 and 3 are the same as for Scenario 1 if the entire 1 MAF of water rights are allocated to applicants. This would happen if the water is worth at least $10/acre-foot (Scenario 2) or $20/acre-foot (Scenario 3) to sufficient water rights users to absorb the full 1 MAF and if the majority of all water rights holders comply with the draft water efficiency best management practices (BMPs). In case the second of these conditions is not met, 300 thousand acre-feet of the 1 MAF will not be issued to new water rights applicants. In that case the hydropower cost drops to $7.9 million to $8.1 million dollars. An even smaller amount of water may actually be applied for if the last 300 kaf is not allocated and the $20/acre-foot fees discourage some applicants. We estimate a low level impact of $7.2 million to $7.4 million for a final water rights allocation of 568 kaf.

Scenarios 4 and 5 will entail essentially no new hydropower costs because there would be no net increased in the amounts of water being allocated from the Columbia river.

FLOOD CONTROL IMPACTS

The Columbia River flood control system involves the drawdown of pools in the late autumn and winter to allow for enough storage space for refill in the spring by snowmelt. Each of the scenarios contemplated involves the diversion of more water from pools, allowing for more space for the refill period. In this sense, each of the scenarios will have no effect on the flood control system. The status quo, scenario 5, involves the highest risk of negative impacts to the flood control system.

IMPACTS ON RIVER NAVIGATION

River Navigation occurs along the lower Columbia and Snake rivers, and consists of two sections: the shallow-draft area upstream from Bonneville dam, and the deep draft navigation area downstream from Bonneville dam. The shallow-draft navigation system is dependent upon stage (river) height to allow for barge traffic to move through the locks unimpeded. Stage height, in turn, is dependent upon river flows. To a large degree, stage height can be and is controlled by the operation of the dams by the Army Corps of Engineers (Corps). The deep-draft navigation system is dependent upon several factors, including spillage from upstream dams, tidal currents, and melting snow.

This report has shown that even in the scenario involving the most amount of diversions, and thus the largest reduction in flows, navigation will be unaffected because river flows are only modestly negatively impacted. Such a reduction in flows will not hinder the Corps from maintaining sufficient stage height at the dams. Discussions with Corps Hydrologists have confirmed that such a reduction in river flows will not affect the deep-draft portion of the river, where navigational disruptions might occur if the flow out of Bonneville dam falls below 70,000 cfs. The reduced flow resulting from the increased diversions is a minimum of 90,000 cfs during March of the dry year examined, well above the flow at which navigational impacts will occur. The scenarios considered in this report will not affect the navigation system of the Columbia River.

COMMERCIAL AND RECREATIONAL FISHING

Additional water diversions from the Columbia river will reduce stream flows slightly, and, depending upon magnitude and timing, these changes in stream flow could affect the survival of migrating salmon and steelhead in the mainstem Columbia river. Whether there is likely to be a significant effect on migratory fish is uncertain, and this is being investigated by a special National Research Council Committee operating under the title “Columbia River Water Resources Management: Instream Flows for Salmon Survival”. Consequently, this report contains no estimates of the effect that changes in Columbia river instream flow will have on the salmon and steelhead runs. Instead, we provide a review and summary of economics information that can be used to value the changes in fish populations that are described by the eventual scientific report. Larger salmon or steelhead runs in the Columbia typically trigger increases in the fishing seasons and catches for both commercial and recreational fisheries. Hence, the value of the fisheries would respond to run size change. The question is "how much"?

Over the past two decades the commercial fishery has experienced wide fluctuations in harvests but steadily declining exvessel prices, largely due to rapid expansion of the salmon farming industry. Because of its higher price ($2.50/lb. in 2002), spring chinook salmon populations have the greatest potential for contributing to incomes and market value of the fishery. Low prices for up-river fall chinook (brights) and lower river fall chinook (tules) ($0.27 to $0.11/lb. in 2002) suggest that there is little net economic value (exvessel price minus fishing costs) associated with changes in fall chinook populations and fishery harvest. Similarly, coho salmon prices have dropped to $0.32/lb., making the that fishery relatively unprofitable. Overall, changes in the size of the salmon runs caused by stream flow effects of water diversions are likely to generate little significant change in the commercial value of salmon supplied to the market and little change in incomes generated by the fishery.

Because recreational fishing values do not decline along with the commercial fishery prices, we would expect the economic value of recreationally caught salmon and steelhead to respond proportionately to moderate changes in run size. One study of the Columbia river and ocean salmon fishery shows a net economic value of $131.40 per fish caught in the ocean, and $84.40 per fish caught in the river (values updated from 1989 to 2002 dollars). To estimate a value of changes in salmon run size due to recreational fishing, we would need to mutliply these values per fish by the fraction of fish caught by anglers.

REGIONAL AND SECONDARY IMPACTS

The 1987 Washington Input-Output model was used to estimate economic impacts of changes in hydropower and agriculture production, and the resulting estimates were updated to 2002 dollars. For the Management Scenario 1 allocation of 1 MAF of new diversion rights, we estimate a direct impact of Statewide agricultural output of $1,223 million, an increase in employment of 12,247, and an expansion of value-added in the State economy of $559.7 million. These direct impacts represent the direct value of increased agricultural production. Because the agricultural sector is linked to suppliers of agricultural inputs (equipment, fertilizers, etc.) and to processors of agricultural products, a change in agricultural production triggers change in the amount of economic activity in these linked sectors. These change are called "secondary impacts". Finally, the increase in incomes caused by direct and secondary income impacts will drive consumer demand for all products, thus causing a tertiary effect, called "induced impacts". The sum total of all three impacts is called "total impact" in the following table.

Table 12.1 Summary of Economic Impacts of Agricultural Sector Expansion ($ millions)

	Output		Employment		Value-Added	
	Direct	Total Impact	Direct	Total Impact	Direct	Total Impact
Scenario 1 (1 MAF)	$1223.7	$2,826.1	12,247	29,869	$559.6	$1345.3
Scenario 2 (700 KAF)	$856.7	$1,974.1	8,569	20,864	$391.7	$939.5
Scenario 3 (569 KAF)	$431.0	$993.9	4,300	10,496	$196.9	$473.0

The economic impact of changes in the hydropower system would stem from reductions in the export of hydropower from the Pacific Northwest, mainly to California during the summer and fall seasons. The reduced sales revenues by Bonneville Power Administration and by the Public Utility Districts along the mid-Columbia river would result in either increased rates or reduced expenditures by the associated public entities. Estimated economic impacts are a reduction in value of regional output of $12 to $19 million, reduced value added of $7 to $11 million, and reduced employment of 67 to 102 jobs.

PASSIVE USE VALUES

Passive use values are held by the public for all manner of economic goods, services, and conditions. These are thought to be particularly significant for public goods that are unique and scarce. Salmon and steelhead populations in the Columbia river qualify as targets for assessment of passive use values. A 1991 estimate of passive use values for salmon and steelhead suggests that a doubling of the fish runs in the Columbia would generate as passive use value of roughly $70 million/year (in 2002 $). A more recent study sponsored by the US Army Corps of Engineers estimates a passive use value for a reduction or 428 in Snake river salmon of $97,360, or $66.28 per fish. Finally, a recent study sponsored by the Washington Department of Ecology estimates a value function that indicates total value (use plus non-use value) for migratory fish populations in the Columbia river basin in Washington State. Applying that value function to a doubling of the fish runs, and extrapolating across the whole population of Washington State, generates a value of $268.08 per fish. This total value would presumably capture both recreational and passive use value.

Once we have an estimate of the likely run size changes caused by increased diversions of water from the mainstem Columbia river, these passive use value estimates could be used to gauge the non-fishery economic values associated with changes in the salmon and steelhead runs. These estimated values should be given weight in decision processes only after careful consideration of passive use values that might attach to other features of the river system and human resources that are affected by the CRI scenarios.

WATER MARKETS

Water markets are an increasingly attractive alternative to regulatory or other non-market mechanisms for resolving disputes over water use and for improving the efficiency of water use. By permitting willing sellers and willing buyers to transfer water, markets will generally shift water from lower valued to higher valued uses. Three types of transactions can accomplish this result. Outright purchases of permanent water rights, temporary leases of diversionary water rights, and transfers of ownership of stored water (typically in a storage reservoir) all facilitate the increase in value of water use. While numerous water transfers of all types have occurred in Washington State, the expansion of water markets is slowed by three obstacles:

1. Third party effects of water transfer, due to shifts in return flows, have to be taken into consideration, possible involving compensation or mitigation.
2. Partly due to third party impacts, the water right that can be transferred needs to be defined in terms of consumptive use, not diversionary right, and this requires documentation and measurement that may not be immediately available.
3. There is often resistance to transfer of water from a traditional use (e.g. agriculture) to another use because of impacts on local communities and cultural attachments to traditional uses.

None of these is a fatal complication, but all three issues highlight the care required in development of a water transfer institution.

Washington State has made the legal changes necessary to permit water transfers. Current law requires that such transfers be submitted to the DOE for review and approval. The ability to retain water rights while temporarily transferring water use to instream flow has also been achieved in Washington. Among other example, we have noted that the Washington Water Trust has purchased and leased water for enhancement of instream flows in such places as Salmon Creek, a tributary of the Okanogan river. And the DOE has a water acquisition program designed to shift water from out-of-stream use to instream flow in chosen locations. All these examples illustrate the principle that increasing transferability of water rights can, given adequate attention to the three issues listed above, work to improve economic efficiency of water use and to improve stream flows.

CONCLUSION

The Columbia River Initiative promises to encompass a number of important developments in the economy and environment of Washington's portion of the Columbia river. While considering increased diversions of water of up to 1 million acre feet, the CRI "management scenarios" also incorporate improved water efficiency and metering requirements, and they propose levying fees for new water users of $10 to $30 per acre-foot per year, with the fee level depending upon the level of threat to salmon runs. The economic review shows that these increased diversions are (a) unlikely to have significant impacts on flood control or river navigation, (b) will have moderately large negative impacts on hydropower production, (c) will have large positive impacts on the agricultural economy and on the regional economy that encompasses agriculture, and (d) might have some negative effects on fisheries and passive use values tied to salmon and steelhead runs. To some degree, the fees proposed under the second and third management scenarios will permit the State to mitigate the effects of increased water diversion on the fish and wildlife resources. Finally, improving and facilitating the exchange of water rights among users through water markets should improve the efficiency of water use and provide opportunities to acquire water for use by fish and wildlife.

APPENDIX A. AGRICULTURAL IRRIGATION BEST MANAGEMENT PRACTICES

Columbia-Snake River

Irrigators Association

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

AGRICULTURAL IRRIGATION BEST MANAGEMENT PRACTICES
FOR CONVERSION OF INTERRUPTIBLE WATER RIGHTS
ON THE COLUMBIA RIVER

INFORMAL COMMENT PERIOD

August 1, 2003 to September 30, 2003

Approximately 330 existing water rights on the Columbia River were issued subsequent to the adoption of an instream flow rule for the river in 1980. These water rights are interruptible during low flow conditions (e.g., drought) in order to retain water in the river. This document is an initial outline of a water use efficiency program that would provide existing water right holders with an option to convert their currently interruptible water right to an uninterruptible water right.

This draft document is being provided to water use efficiency experts, water users that may choose to participate in the program, and other stakeholders interested in water management on the Columbia River for review and comment. Written comments on this draft should be provided by **September 30, 2003** to**:**

Darryll Olsen, PhD, Board Representative
Columbia Snake River Irrigators Association
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and/or

Lynn Coleman, P.E.
Washington Department of Ecology
(360) 407-6738
Email: lcol461@ecy.wa.gov

After this initial round of review, this document will be revised in response to comments, and additional program details and rule language will be developed for further public review as a part of a formal state rule making process.

This document was developed jointly by the Columbia Snake River Irrigators Association (CSRIA) and the Washington Department of Ecology (Ecology) under the terms of a settlement agreement executed in 2002. Under the settlement agreement, CSRIA and Ecology agreed to develop a water use efficiency program as an option for irrigation and industrial water users with water rights issued after 1980 to convert their water rights to an uninterruptible status.

> Participation in this water use efficiency program would be voluntary. Water users that choose not to participate would see no change in their existing water rights.

The proposed best management practices (BMPs) vary according to the number of acres being irrigated. The BMPs for water users with fewer acres would be less expensive and simpler to implement when compared to the BMPs for larger users.

In exchange for converting to an uninterruptible water right, the proposed draft rule would require that the water saved as a result of implementing the efficiency program be transferred to

Ecology or its designee for placement in the state's trust water right program. A proposed process for evaluating the savings and transferring the saved water is still under development.

Also under development is the process for a water right holder to enroll in the program. It is expected that the program will provide a process for approving alternative technologies to better tailor the BMPs to site-specific conditions.

The roles of Ecology, CSRIA, other government agencies, and other agricultural organizations, in the implementation of this program have not been determined. The program may include assistance and other functions to be performed by local conservation districts, and discussions are planned with the Natural Resources Conservation Service regarding their possible role.

Per the terms of the settlement, Ecology agreed to propose a water use efficiency program in the form of a rule as a part of the broader program for water management on the Columbia River, known as the Columbia River Initiative.

A final rule resulting from the Columbia River Initiative is scheduled to be adopted in 2004. For more information on the Columbia River Initiative, please visit the web site at: http://www.ecy.wa.gov/programs/wr/cri/crihome.html or call Gerry O'Keefe at (360) 407-6640.

AGRICULTURAL IRRIGATION BEST MANAGEMENT PRACTICES FOR CONVERSIONS OF INTERRUPTIBLE WATER RIGHTS ON THE COLUMBIA RIVER

INFORMAL COMMENT PERIOD

August 1, 2003 to September 30, 2003

Mainstem Columbia River water users are given an option of advancing water use and efficiency practices, known as “best management practices” (BMPs), as part of a new water management program.

Through participation in this efficiency program, existing mainstem water users with water rights that are presently subject to instream flow levels established in 1980, can convert their interruptible water rights into uninterruptible water rights.

The “best management practices” for water management and operation are described below. These practices cover diversion and distribution systems, application systems and technology, crop and water management, new research, development and demonstration projects, and benefits for fish, wildlife, and environmental resources.

Participation in the program is voluntary.

The efficiency program classifies existing water right holders into three sectors, with appropriate BMPs associated with each water user sector.

A. The sectors are:

i. Small Public Sector Irrigation. Public sector entities--municipalities, schools, public service districts, or state agencies--with less than 25 acres under irrigation, with water rights for a single contiguous site.

ii. Other Small Irrigation. Public sector entities (26-100 acres) or small privately owned irrigation (100 acres or less).

iii. Large Irrigation. Irrigators with more than 100 acres under irrigation.

B. Small Public Sector Irrigation:

i. Primary irrigation to occur during night irrigation schedules.

ii. Use of timed irrigation sets to apply irrigation water based on turf/crop consumptive demand, estimates updated monthly.

iii. Conveyance losses from the source diversion to the point of application shall not exceed 15% of the total diversion.

iv. On-site application efficiency shall not be less than 70%, under average operating conditions.

C. Other Small Irrigation.

i. Use of timed irrigation sets to apply irrigation water based on turf/crop consumptive demand, estimates updated monthly.

ii. Conveyance losses from the source diversion to the point of application shall not exceed 15% of the total diversion.

iii. On-site/farm application efficiencies shall not be less than the efficiencies shown in Table 1.

Table 1

Irrigation Technology	Direct Machine Efficiency*
Solid Set (above canopy)	65%
Solid Set (below canopy or row crop)	70%
Wheel-Line or Hand-Line (impact sprinkler)	65-70%
Traveling Gun-Single Nozzle	65%
Center Pivot (over-head impacts, >25 psi)	75%
Center Pivot (drop tube <25 psi)	85%
Micro-Sprinkler	85%
Drip-Precision Irrigation	90-95%

* Source: Technical Memorandum from Benton County Water Conservancy Board to WADOE ERO and CRO Water Resources Program Staff, Revised Table for Efficiency Factors for Use Under 90.03.380, Efficiency Estimates Minus Return Flows, Dated May 4, 2000, Kennewick, WA; and Sources and Citations Therein.

D. Large Irrigation:

i. Pumping plants shall use multi-speed drives or high efficiency motors for the specific system configuration, with annual computer monitoring to enhance energy and water use efficiency for larger systems; any noncompliance issues will be rectified within a reasonable compliance period.

ii. All main transmission/distribution systems are closed, pressurized systems, with conveyance losses less than 5%.; all systems incorporate friction reducing components or energy efficiency engineering; any noncompliance issues will be rectified within a reasonable compliance period, or the water right holder agrees to meeting full system compliance at next technology change or retrofit cycle.

iii. All conventional standards for crop water-use are met or exceeded (water use measured in annual inches of consumptive use and evapotranspiration, by crop and by micro-climate area), as established by the WSU crop water use requirements (1991 edition and technical appendices) and WSU Public Agricultural Weather Systems data.

iv. On-site/farm application efficiencies shall not be less than the efficiencies shown in Table 1. By 2015, the minimum on-farm application efficiency (farm average), in Table 1, shall be 75%.

v. By 2015, drip irrigation and precision irrigation systems shall be introduced where crop types and technology allow.

vi. Soil moisture sensors and probes (and/or other remote sensing technologies) shall be employed for monitoring water needs; these data shall be reviewed jointly with real-time weather forecast data to establish daily, and near-term, irrigation schedules; any noncompliance issues will be rectified within three years of operation under rule compliance.

vii. For tree fruit crops, cover crops (or other practices) shall be allowed to reduce water evaporation (from temperature cooling) and reduce soil erosion; any noncompliance issues will be rectified within a reasonable compliance period.

viii. Cultivation practices shall be used to enhance water infiltration and eliminate soil erosion.

ix. Water management shall be used to reduce chemical and fertilizer application rates per acre, and it is a component of integrated pest management regimes (where applicable and cost-effective) to improve the effectiveness of biological controls and reduce pest habitats.

x. Water Right holders are encouraged to introduce and experiment with variable rate irrigation practices--acre-to-acre systems--and new forms of precision application and emitter controls.

xi. Water Right holders are encouraged to introduce and experiment with computer monitoring of irrigation systems for both efficiency and performance measures.

xii. Water right holders are encouraged to introduce and experiment with underground drip application systems for broad commercial applications, for some crops.

xiii. Water right holders are encouraged to introduce, experiment with, and document the effectiveness of, new soil conditioning products ("soil soap" or "wet soil" products); commercial applicability will be determined based on project monitoring, performance and cost-effectiveness.

xiv. Water right holders are encouraged to develop wildlife habitat and refuge areas, where cost-effective.

xv. Water right holders are encouraged to develop synergistic projects related to irrigation water management and improvements to fish habitat and rearing grounds.

E. All of the water user sectors shall comply with fish screening and water measuring standards, as stated below:

i. Water diversion facilities are screened and approved by the Washington Dept. of Fish and Wildlife, pursuant to RCW 77.16.220, RCW 77.55.040, and RCW 77.50.070; existing screen configurations are consistent with mid-1990s standards; facilities are inspected and maintained annually; any noncompliance issues will be rectified within an approved compliance period.

ii. Source water diversions are metered as described in the rule "Requirements for Measuring and Reporting Water Use," Chapter 173-173 WAC. Water users shall report monthly water use totals and monthly peak diversions to the Dept. of Ecology using one of the available electronic reporting methods.

APPENDIX B - CROPPING TRENDS

Introduction

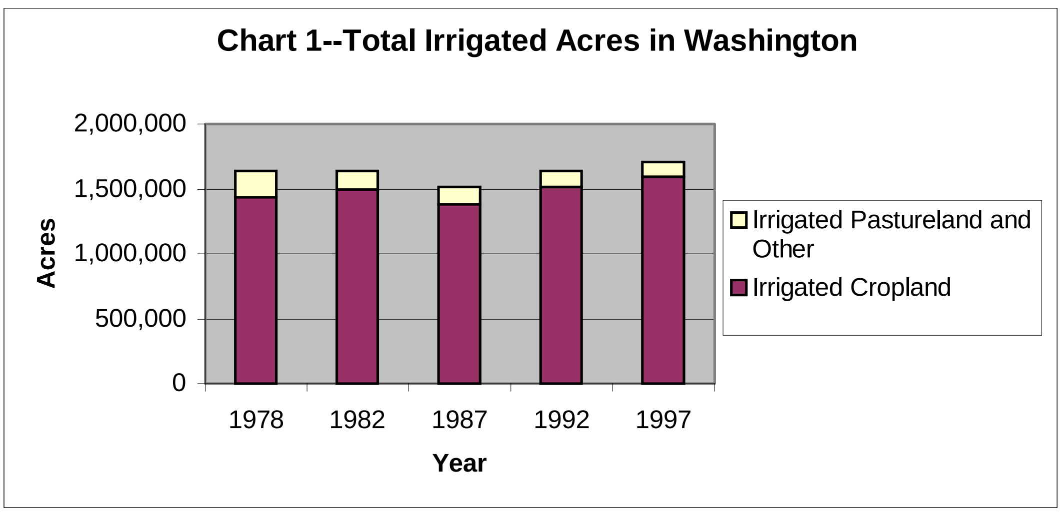
The purpose of this Appendix is to describe recent and long-term trends in Washington state agriculture with the hope of predicting the dollar value of additional agriculture if new irrigable land were to be developed with the diversion of additional water from the Columbia River. The focus here is use crop patterns on existing irrigated acreage to ascertain how many acres and what crops will be harvested. After identifying what crops will most likely be planted in different regions of the state, we will look at the Department of Ecology's (Ecology) backlog of water right applicants in order to more accurately predict the value of the additional water in irrigated agriculture should these applicants receive new water rights.

The primary sources for the data used in this report are the *Census of Agriculture* from 1978 report to the most recent 1997 report, and the *Washington Agricultural Statistics* from the 1996-1997 report to the most recent 2002 report. The *Census of Agriculture* is reported approximately every 5 years. This report contains data from the 1978, 1982, 1987, 1992, and 1997 census years. The U.S. Department of Commerce has authored all of the census years used in this report, with the exception of the 1997 report, which for the first time was authored by the U.S. Department of Agriculture. The Census reports are used to establish the long term trends in Washington agriculture. The *Washington Agricultural Statistics* are annual bulletins authored by the Washington Agricultural Statistics Service. This report contains data from the 1996-1997, 1997-1998, 1999, 2000, 2001, and 2002 annual bulletins. Additionally, each annual bulletin focuses on a different crop which is referred to as the "Highlighted Commodity." This report will frequently reference the "Highlighted Commodity." This data is used primarily to look at more recent trends in Washington agriculture.

Long-Term Trends

This section will focus on the trends in irrigated acreage over the last 20 to 25 years. This section will examine both state totals and county level acreage trends starting from the 1978 census year. Additionally, we distinguish between harvested cropland and pastureland. Again, detailed explanations of how the Census of Agriculture defines the terms used in this report are available in Appendix I.

Chart 1 shows the trends in irrigated acreage for all of Washington state. Chart 2 through Chart 14 show the same trends for counties relevant to diversion of water from the Columbia River. In the case of Ferry county for 1992, data is not available to avoid disclosing data for individual farms.



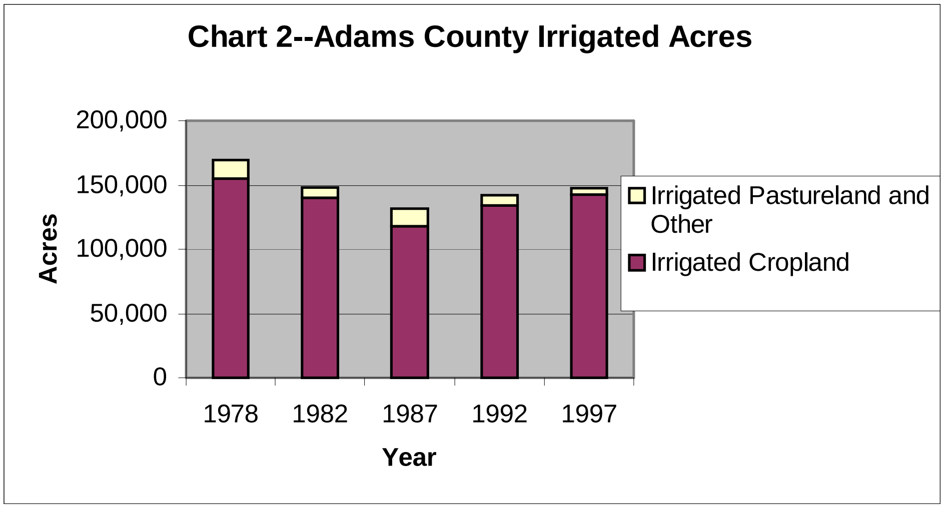


Chart 2--Adams County Irrigated Acres
200,000
150,000
100,000
50,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

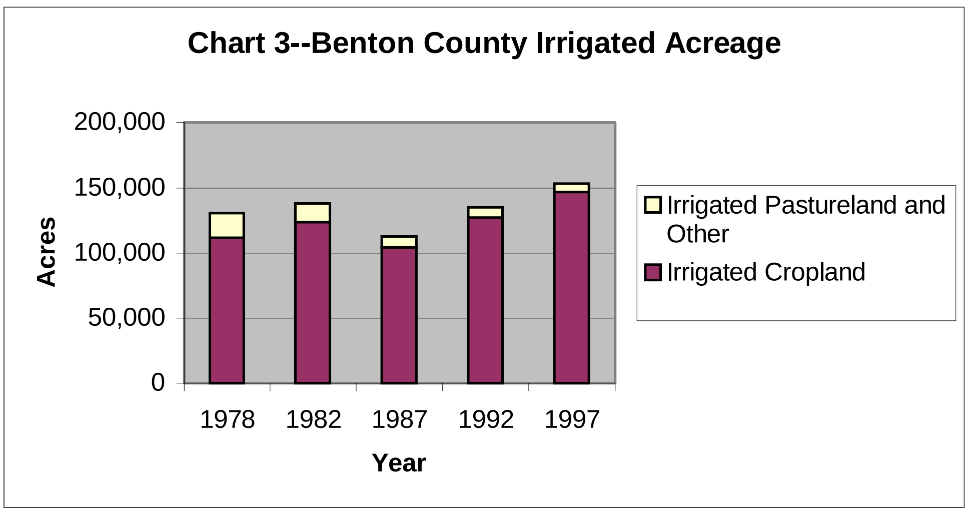


Chart 3--Benton County Irrigated Acreage
200,000
150,000
100,000
50,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

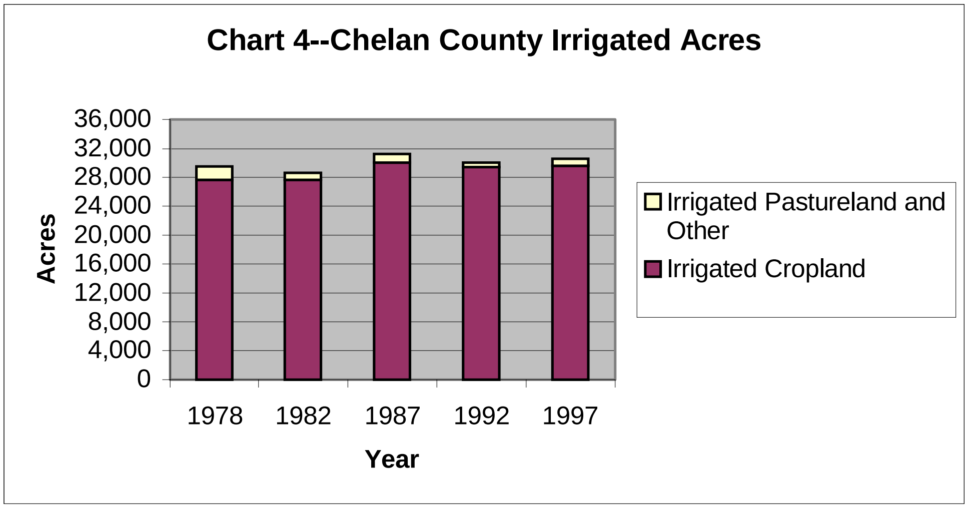


Chart 4--Chelan County Irrigated Acres
36,000
32,000
28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

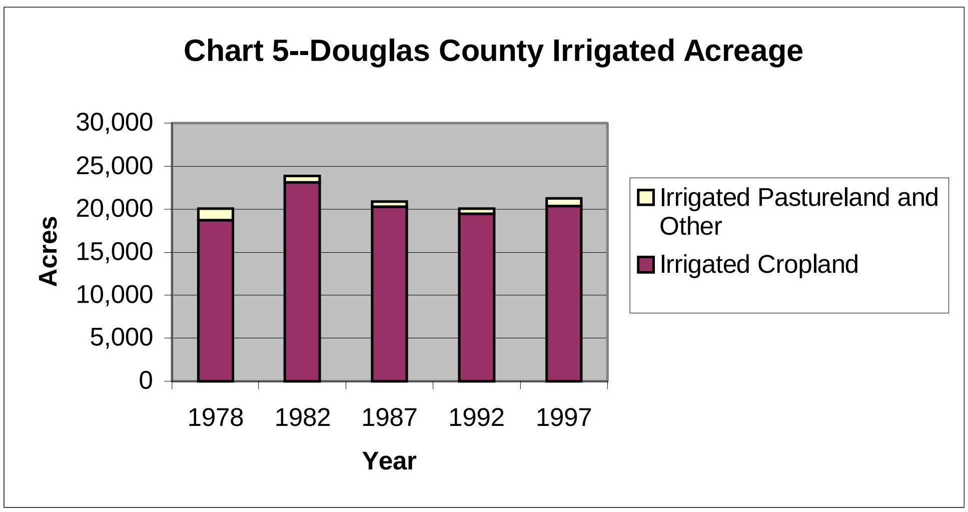


Chart 5--Douglas County Irrigated Acreage
30,000
25,000
20,000
15,000
10,000
5,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

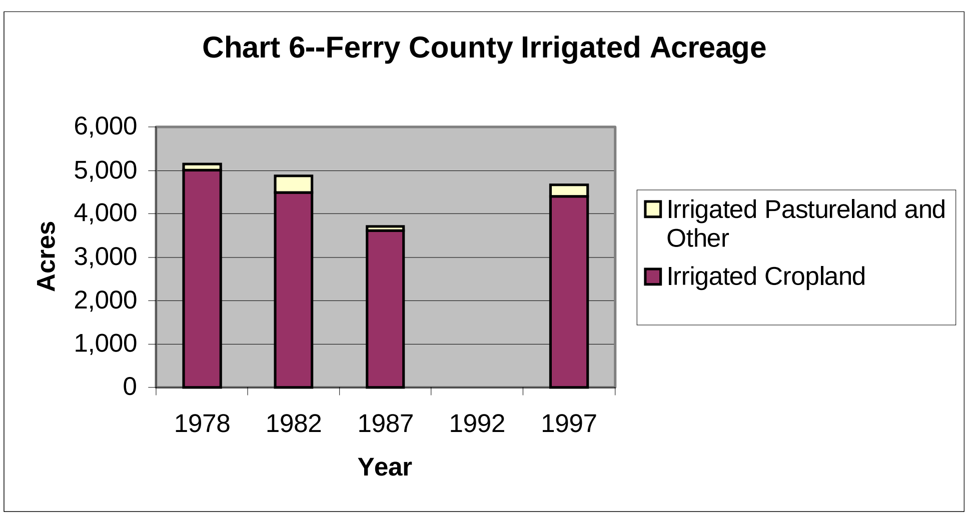


Chart 6--Ferry County Irrigated Acreage
6,000
5,000
4,000
3,000
2,000
1,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

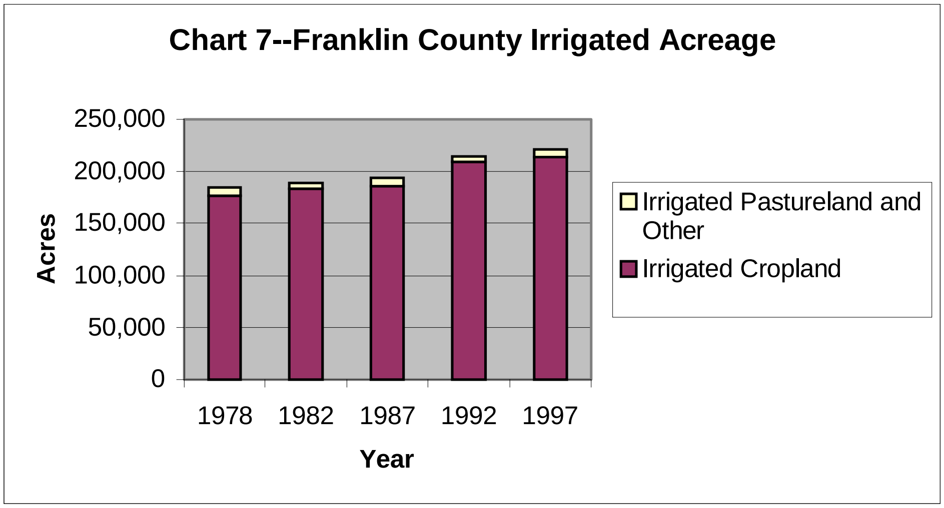


Chart 7--Franklin County Irrigated Acreage
250,000
200,000
150,000
100,000
50,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

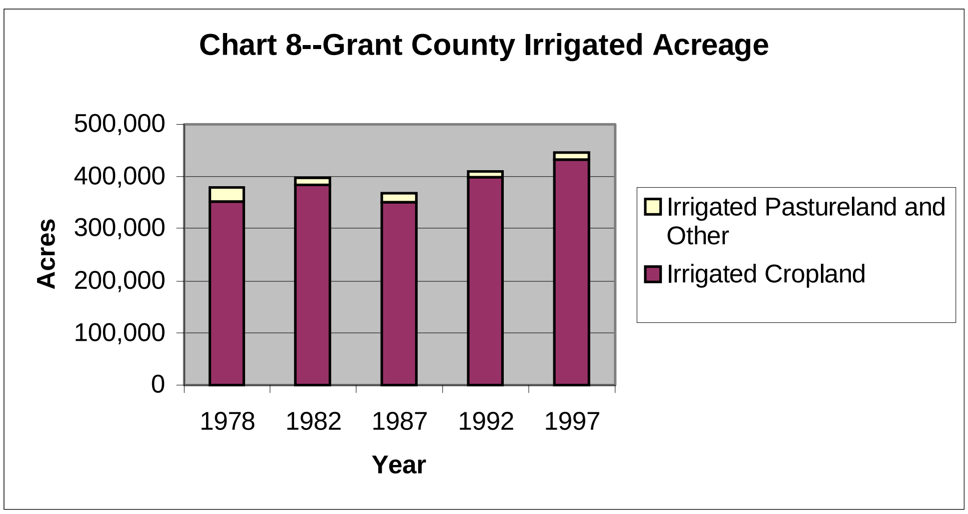


Chart 8--Grant County Irrigated Acreage
500,000
400,000
300,000
200,000
100,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

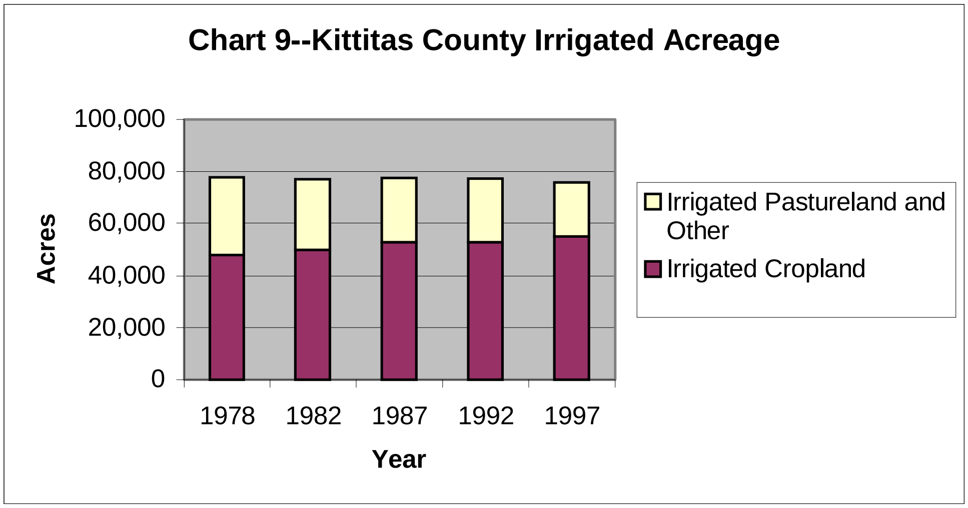


Chart 9--Kittitas County Irrigated Acreage
100,000
80,000
60,000
40,000
20,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

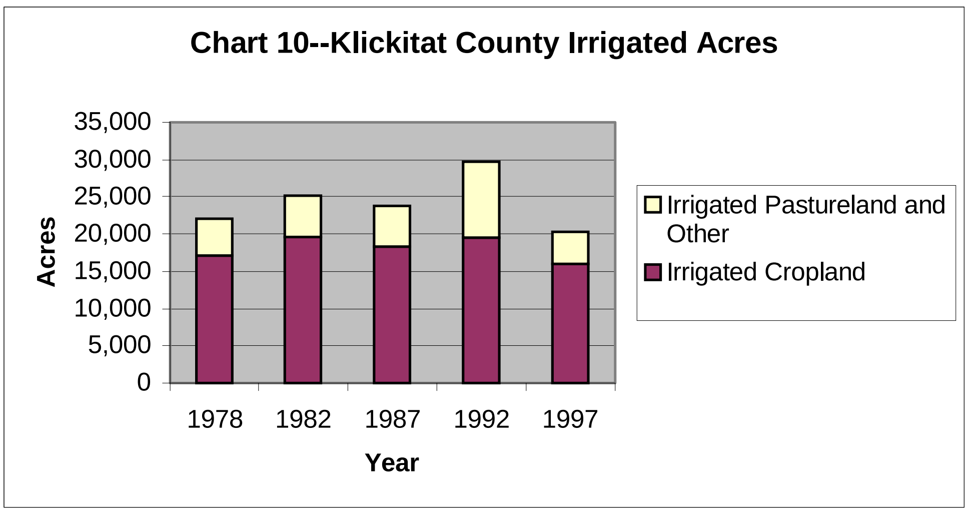


Chart 10--Klickitat County Irrigated Acres
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Acres
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

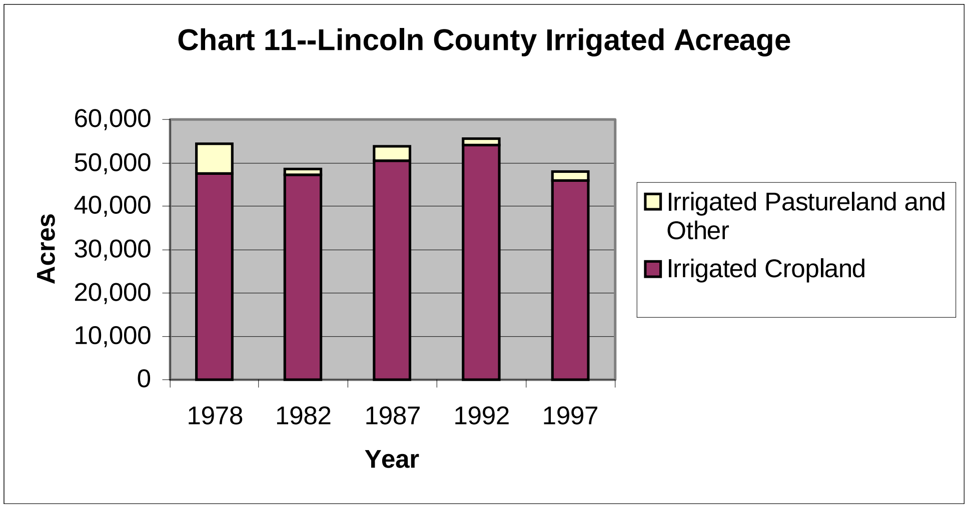


Chart 11--Lincoln County Irrigated Acreage
Acres
60,000
50,000
40,000
30,000
20,000
10,000
0
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

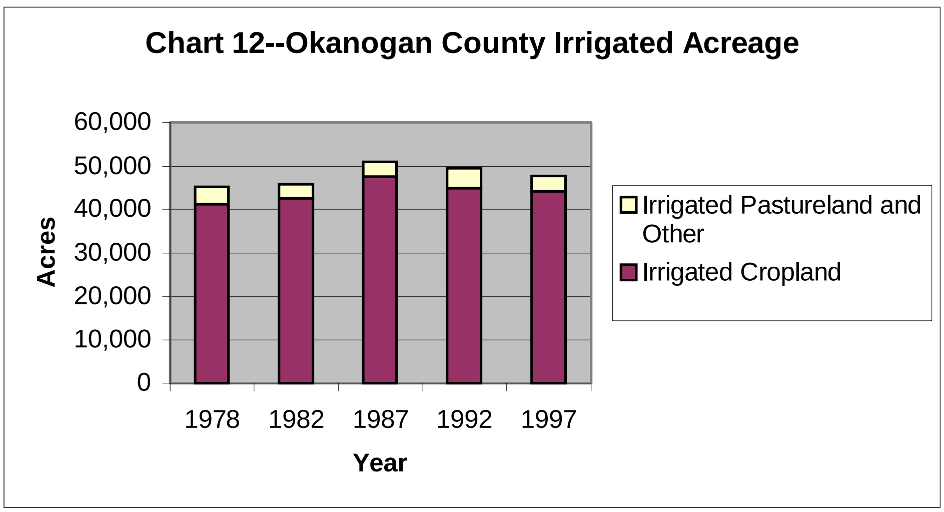
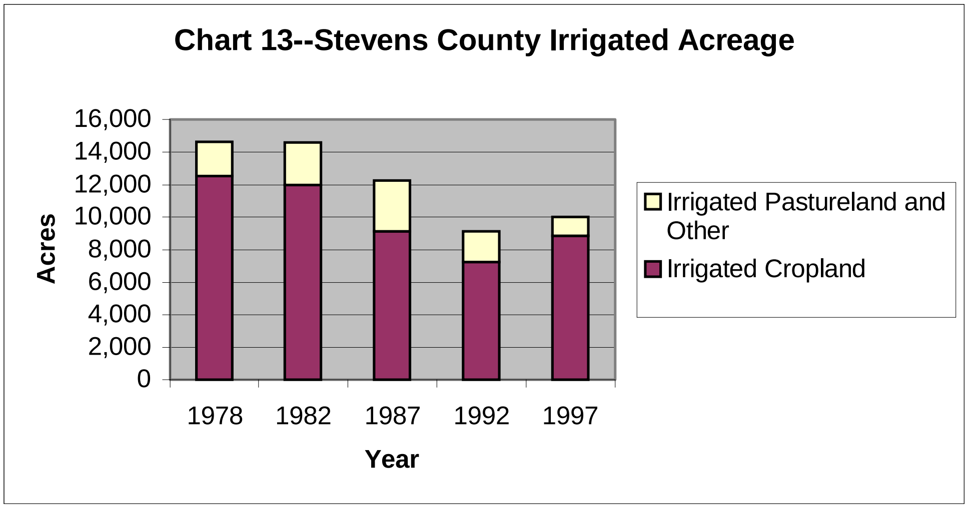
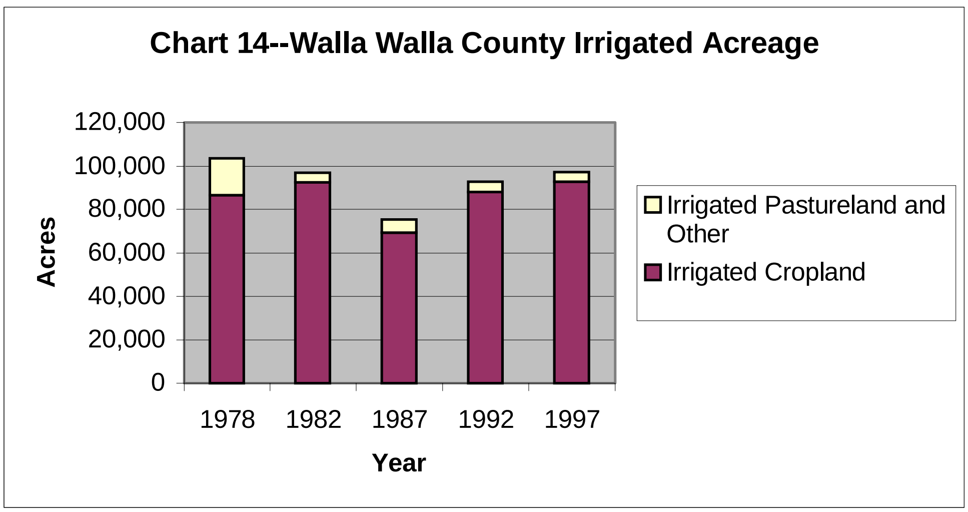


Chart 12--Okanogan County Irrigated Acreage
Acres
60,000
50,000
40,000
30,000
20,000
10,000
0
1978
1982
1987
1992
1997
Year
Irrigated Pastureland and Other
Irrigated Cropland

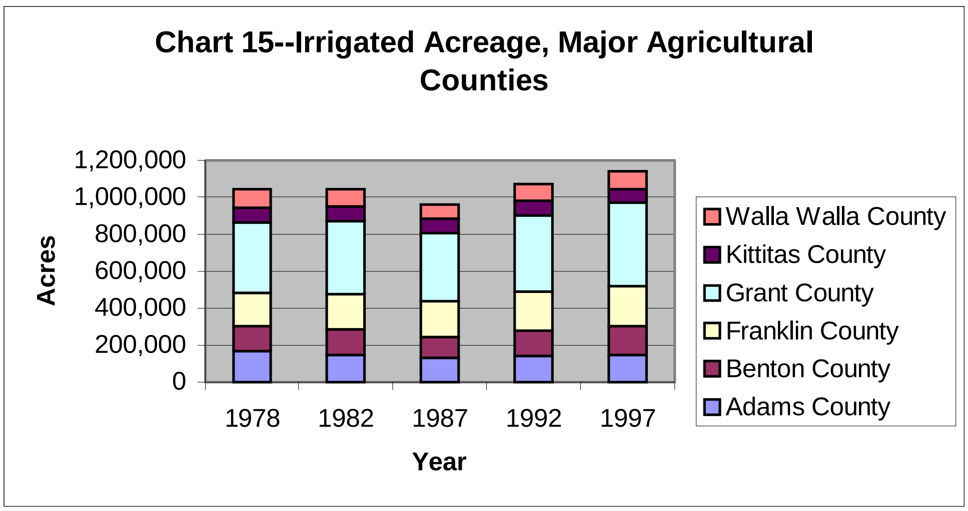




Total irrigated acres in Washington have remained relatively stable over the past 20 years, and irrigated pastureland as a proportion of total irrigated land has remained roughly the same. Total irrigated acres hit a maximum of 1,705,025 in 1997 and bottomed out in 1987 for the sample period examined.

When looking at the county level irrigated acreage totals in Chart 2 through 14, there are a couple of things worth noting. Adams, Benton, Franklin, Grant, Kittitas, and Walla Walla counties emerge as the major agricultural counties, together accounting for 67% of the total irrigated acres in Washington. Furthermore, some of these counties contain far more pastureland as a proportion of irrigated acres, most notably Chelan, Kittitas, Klickitat, and Stevens counties.

Chart 15 shows the distribution of acreage in the above mentioned counties that emerge as the major agricultural counties. Grant County is the leader in irrigated acreage. Acreage shown is total irrigated acres, that is, irrigated cropland and irrigated pastureland and other combined.



The charts below breakdown each major agricultural county, and the crops grown in those counties for the 1997 *Census of Agriculture*. Note that the "other" category tends to be a rather large percentage of the total crops grown in many of the regions. This is for two main reasons. First, the census data withholds some data to avoid disclosing numbers for individual farms when there are 3 or fewer farms growing a particular crop in a particular county. Second, when there are very few irrigated acres for a crop in a particular county, the census groups these acres into an "all other counties" category. Whenever possible, this report identifies the crops concealed by the census bureau.

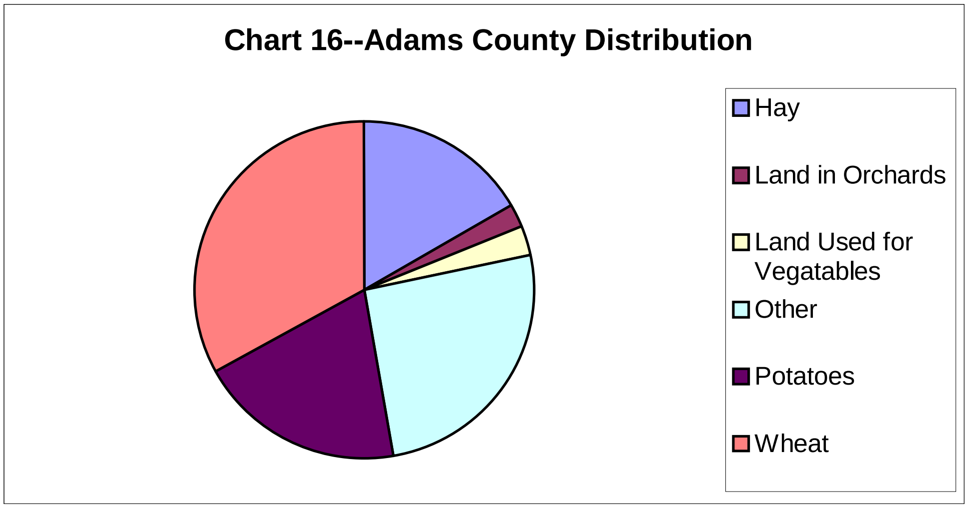


Chart 16--Adams County Distribution
Hay
Land in Orchards
Land Used for Vegatables
Other
Potatoes
Wheat

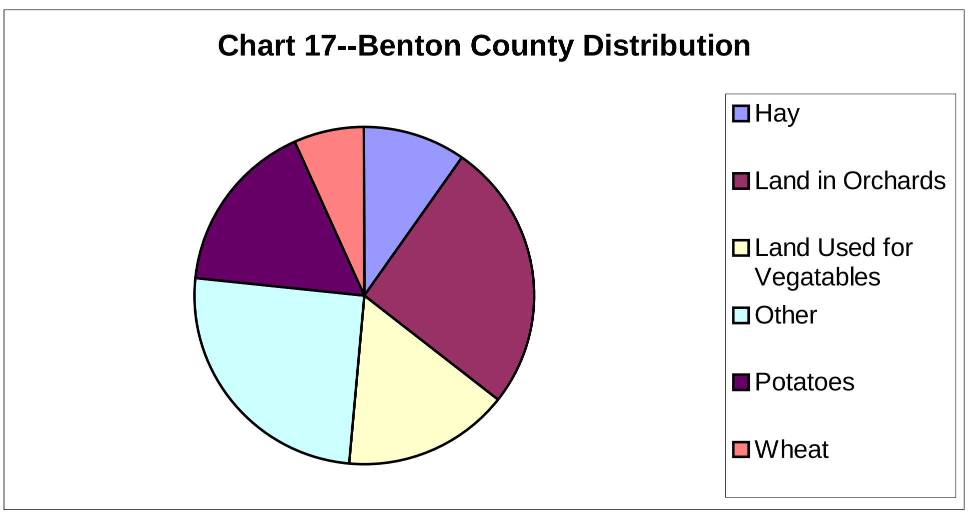


Chart 17--Benton County Distribution
Hay
Land in Orchards
Land Used for Vegatables
Other
Potatoes
Wheat

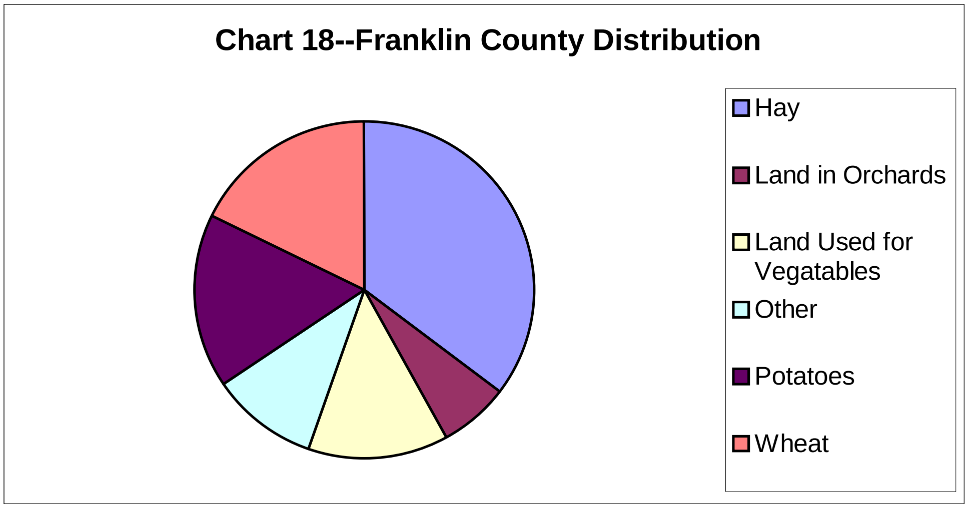


Chart 18--Franklin County Distribution
Hay
Land in Orchards
Land Used for Vegatables
Other
Potatoes
Wheat

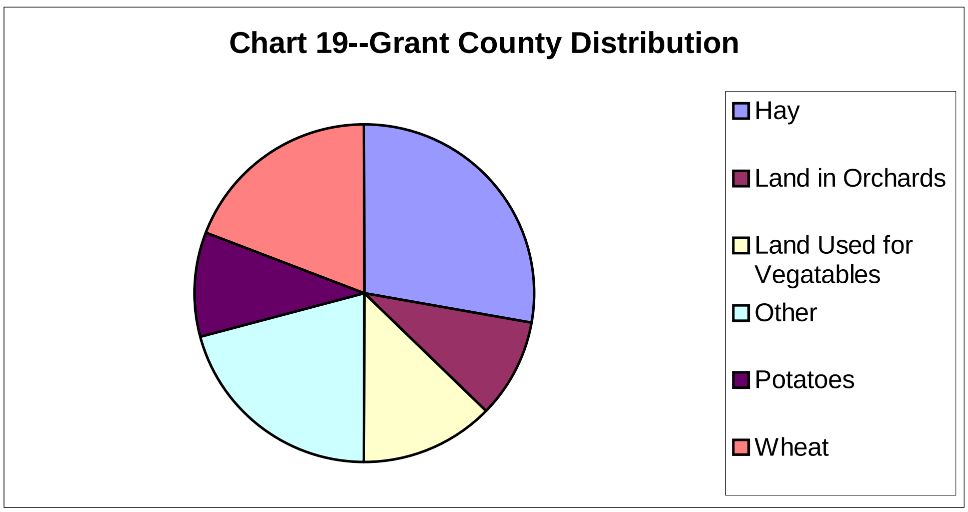
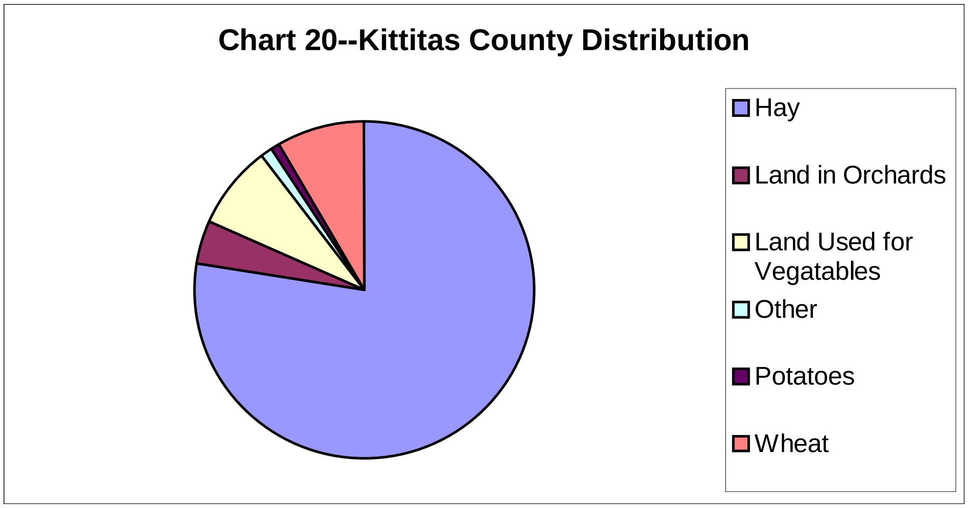
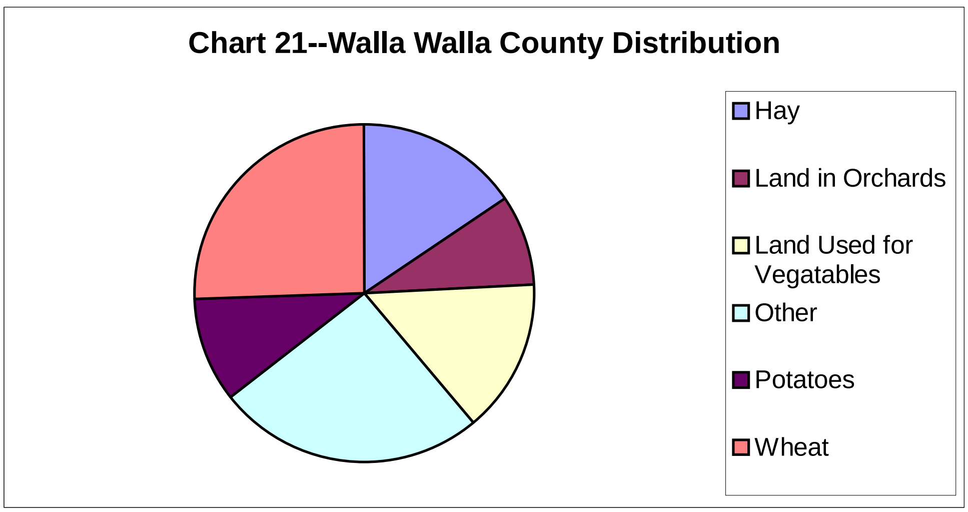


Chart 19--Grant County Distribution
Hay
Land in Orchards
Land Used for Vegatables
Other
Potatoes
Wheat





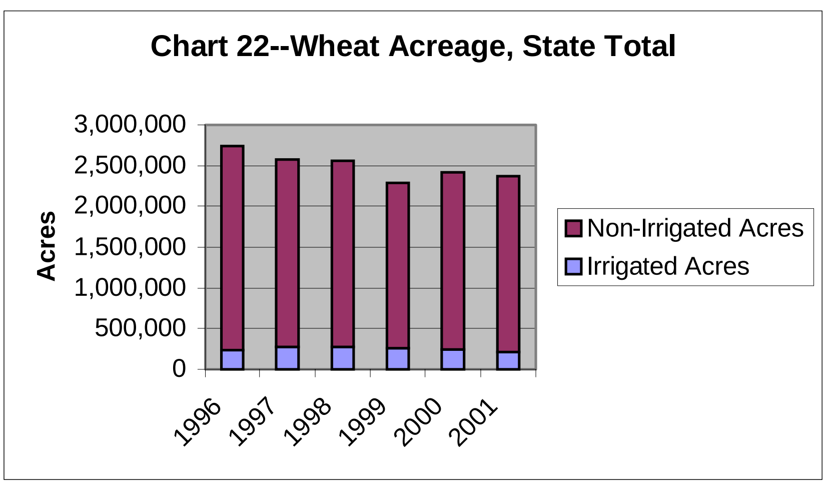
The purpose of showing the breakdown of crops by county for the most recent census year is to have a basis of comparison for the more recent agricultural trends that this report will focus on next. Recall that the primary source for the upcoming section is the WASS *Washington Agricultural Statistics* annual reports, not the *Census of Agriculture*.

<u>Recent Trends</u>

Ideally, we would like to show trends in the last 5 or 6 years of irrigated acreage by county, and by crop, to get a better idea of what crops would be produced if new water rights were to be issued in a particular county. However, since the most recent *Census of Agriculture* was in 1997, we have to turn to another source. The WASS publishes an annual crop report entitled *Washington Agricultural Statistics*. The report shows harvested acreage by crop for the state as a whole. For some, but not all crops, the report also breaks down harvested acreage by county, where the crop is relevant to the county. Some crops of relevance, such as grapes, apples, and all fruits are left out all together. Furthermore, irrigated acreage data is sparse in the WASS annual reports. For these reasons, this report will focus on recent trends in Washington Agriculture on a crop by crop basis. Whenever possible, county data are presented for counties relevant to Columbia River irrigation. Other sources are also used that are available on the WASS website. The documents referenced in this section are *Washington Agricultural Statistics* for the years 1997-1998 to 2002, the 2002 Wine Grape Acreage Survey, and the Washington 2001 Fruit Tree Survey.

Wheat

Below are charts showing total harvested acres of wheat and the portion that is irrigated acres for all wheat. A state total is shown along with counties relevant to the Columbia River whenever possible. If a county is not shown, data at the county level was not available. Irrigated acres is a very small proportion of the total acres harvested in nearly every case.



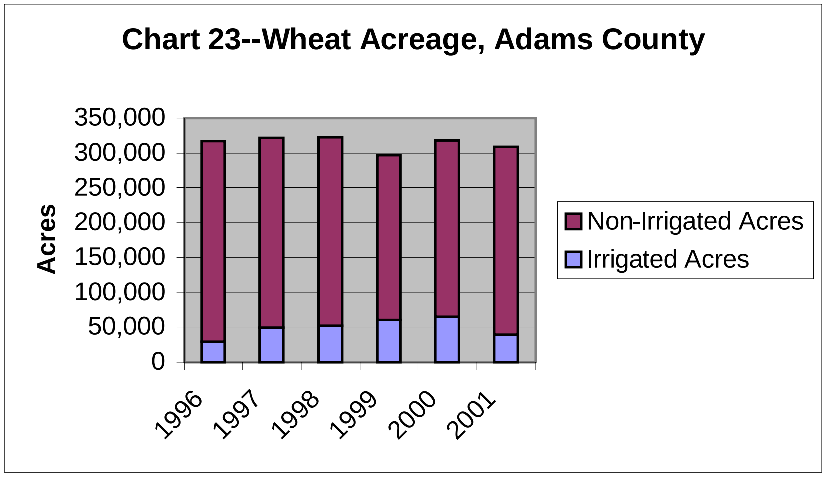


Chart 23--Wheat Acreage, Adams County
Acres
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1996
1997
1998
1999
2000
2001
Non-Irrigated Acres
Irrigated Acres

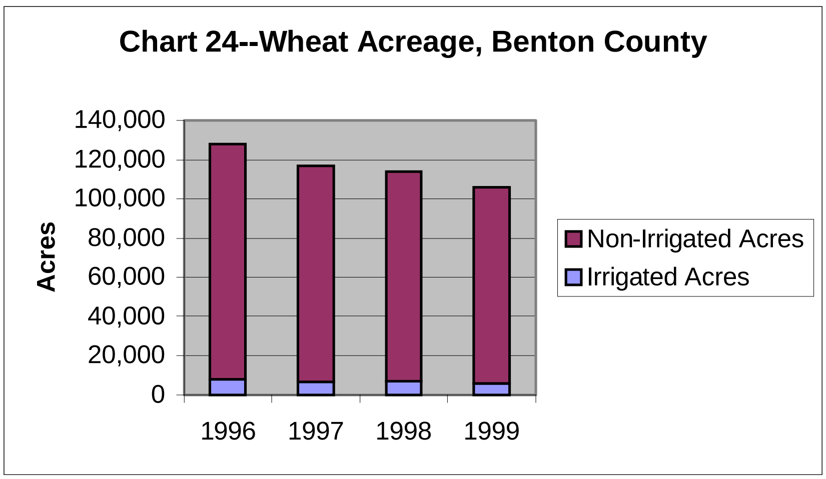


Chart 24--Wheat Acreage, Benton County
Acres
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1996
1997
1998
1999
Non-Irrigated Acres
Irrigated Acres

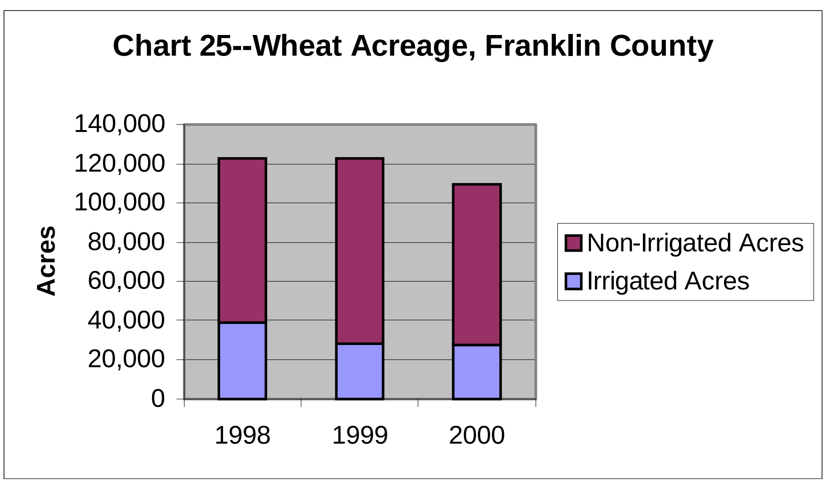
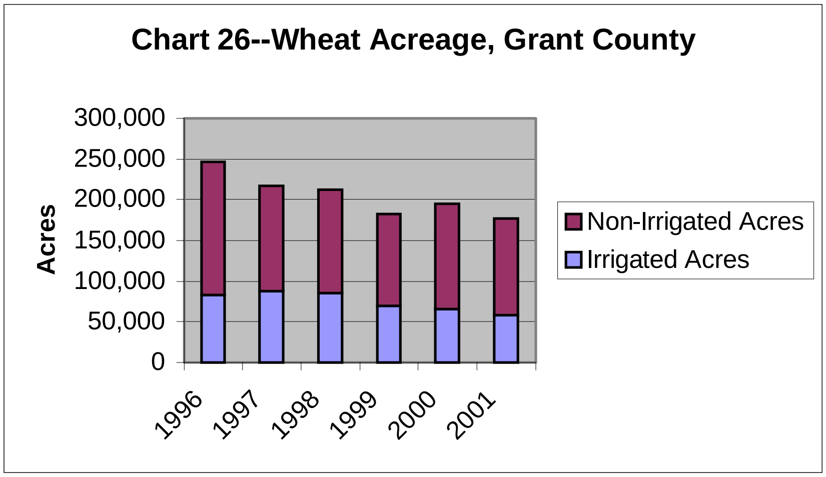
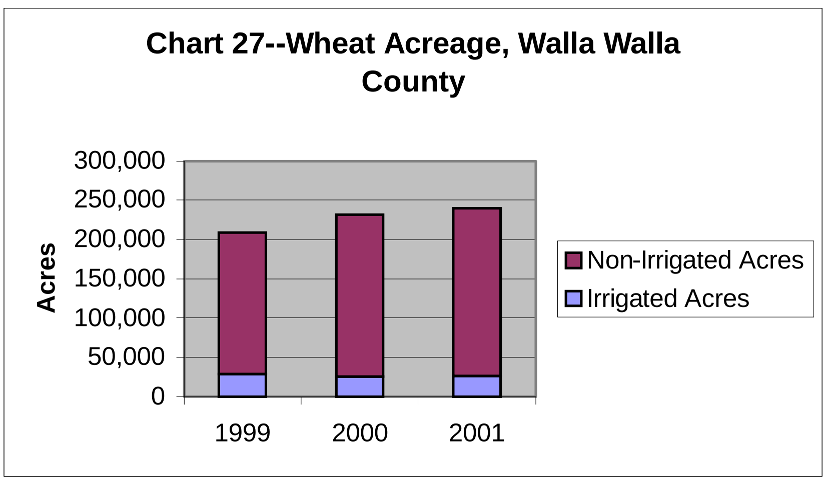


Chart 25--Wheat Acreage, Franklin County
Acres
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1998
1999
2000
Non-Irrigated Acres
Irrigated Acres

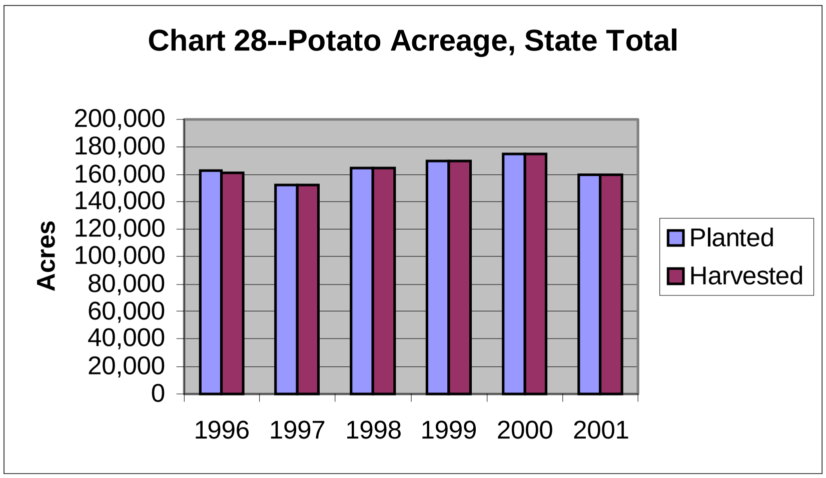


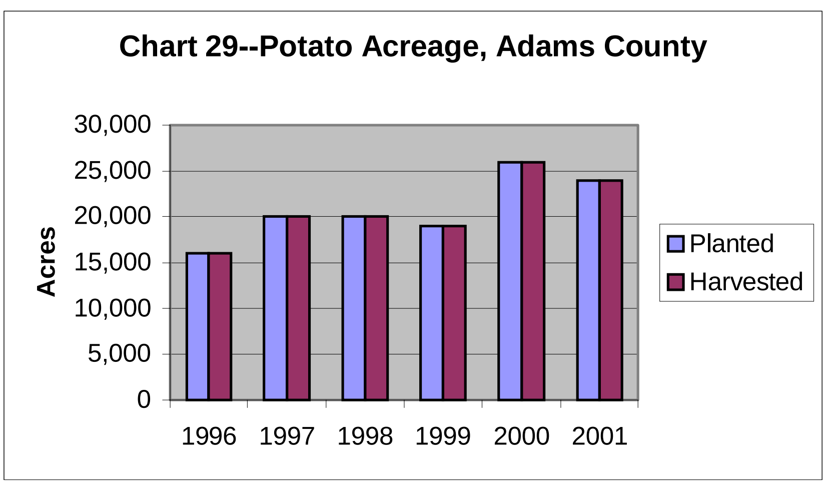


These charts provide evidence that although wheat is a major crop for Washington State, it is primarily a dry land crop, and little irrigation is needed. This fact, matched with a generally a slightly downward trend in wheat in the last few years, would suggest that large portions of additional water made available for irrigation is unlikely to go into wheat production. Similar trends exist for grains that make up a smaller portion of total acreage, such as barley and oats.

Potatoes

Irrigated acreage in potatoes was not available in the WASS reports. Potato acreage was down drastically from 2000 to 2001 for the state as a whole as a result of the 2001 drought. However, potatoes exhibited an upward trend in the late 1990s. Furthermore, the 2001 drought had less severe effects on counties relevant to the Columbia River. The trend in most of these counties, although slightly downward, seems less sensitive to drought years than the state as a whole. Charts 28-33 show recent trends in potatoes.





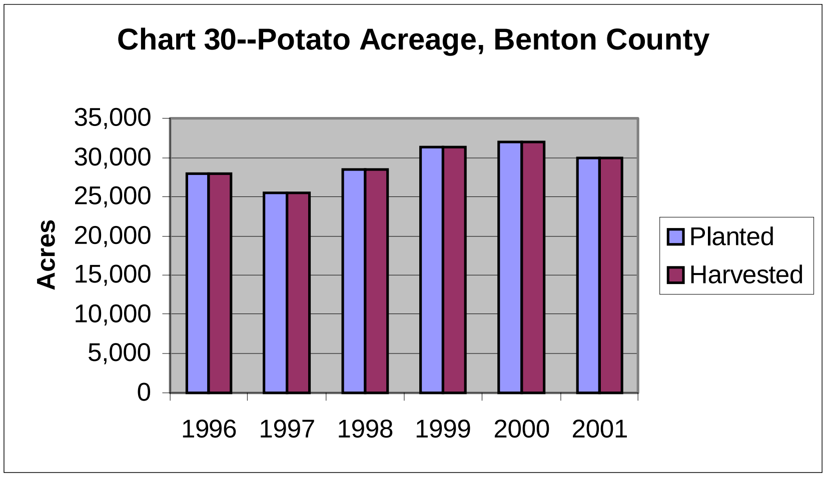


Chart 30--Potato Acreage, Benton County
Acres
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1996
1997
1998
1999
2000
2001
Planted
Harvested

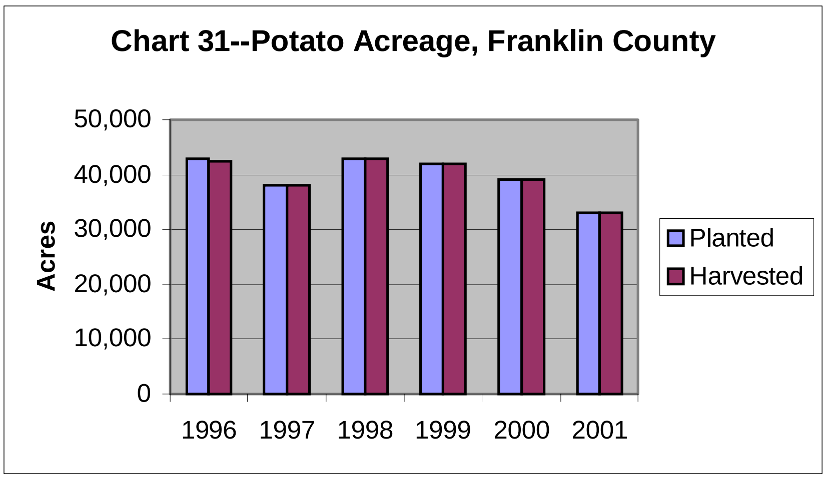
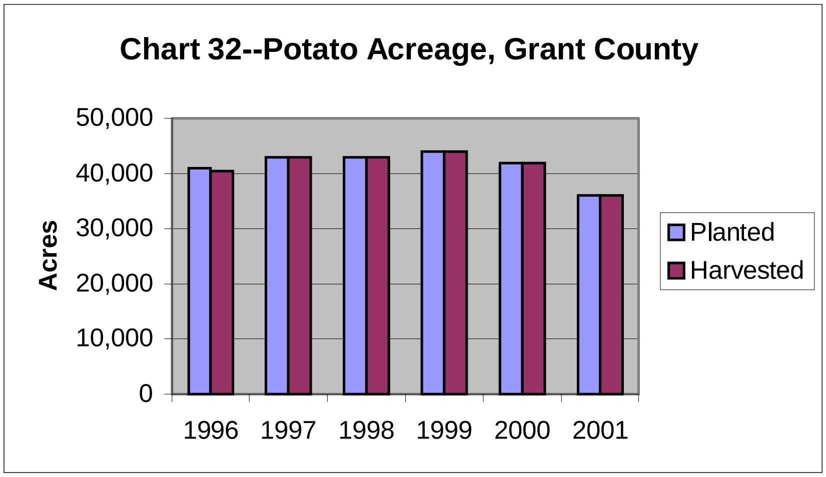
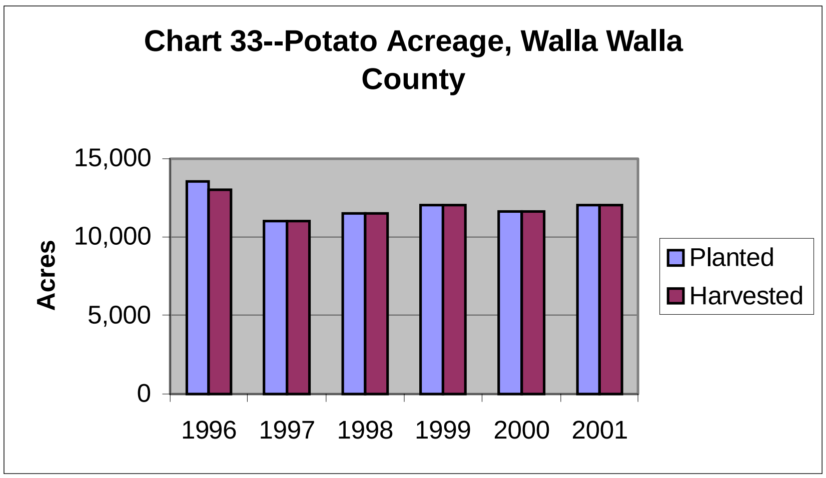


Chart 31--Potato Acreage, Franklin County
Acres
50,000
40,000
30,000
20,000
10,000
0
1996
1997
1998
1999
2000
2001
Planted
Harvested



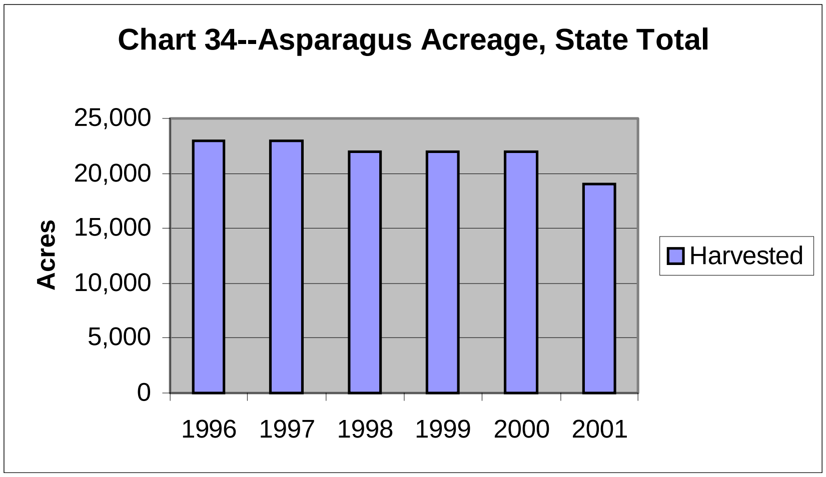


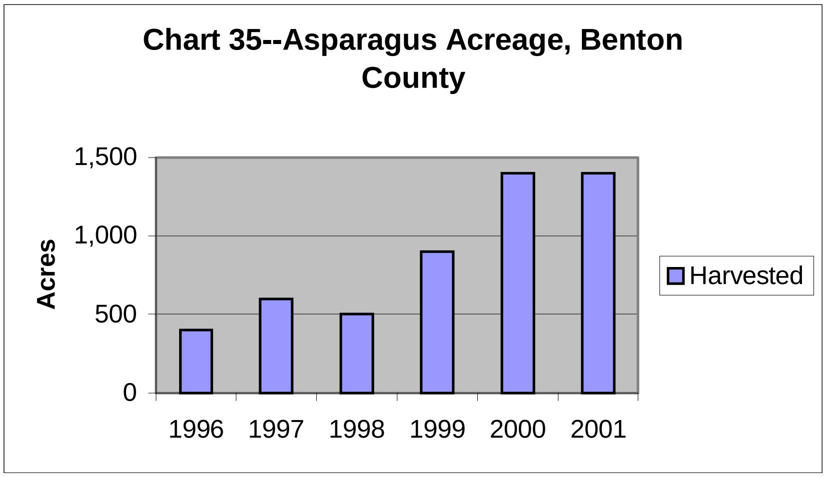
<u>Selected Vegetables</u>

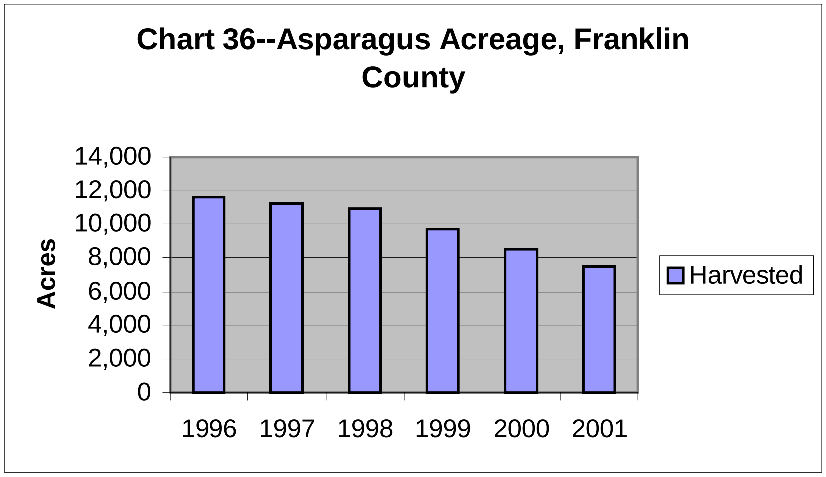
The WASS annual reports provide harvested acreage, but not irrigated acreage, for selected vegetables at the county level. Many of the counties shown are relevant to the Columbia River, and furthermore, the counties relevant to the Columbia River account for the vast majority of the state total. Generally speaking, trends are mixed, and many times the harvested acreage is down from 2000 to 2001, likely due to drought.

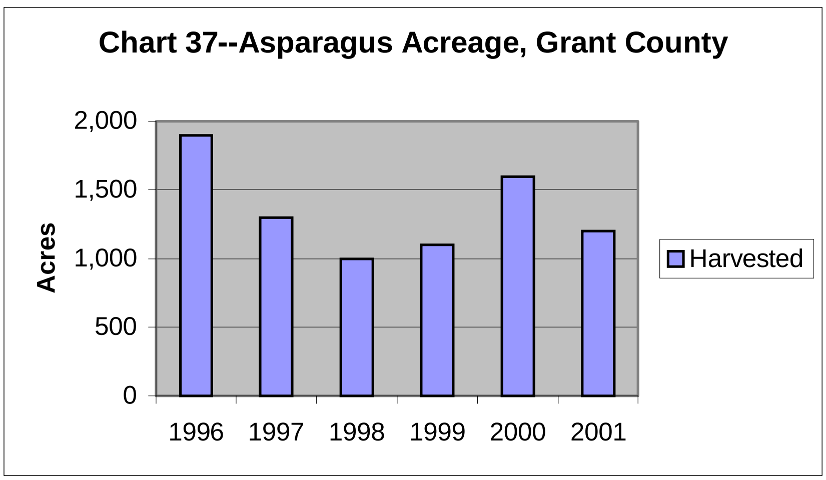
<u>Asparagus</u>

The state trend in asparagus is apparently level and steady in the late 1990s, with a decrease from 2000 to 2001. County level trends are mixed: general upward trend for Adams and Benton counties, and downward for Franklin and Walla Walla counties. Grant County displays a downward trend from 1996-1998, an upward trend from 1998-2000, and back down for 2001. Adams, Benton, Franklin, Grant, and Walla Walla counties accounted for only 28% of the total harvested acres in asparagus.



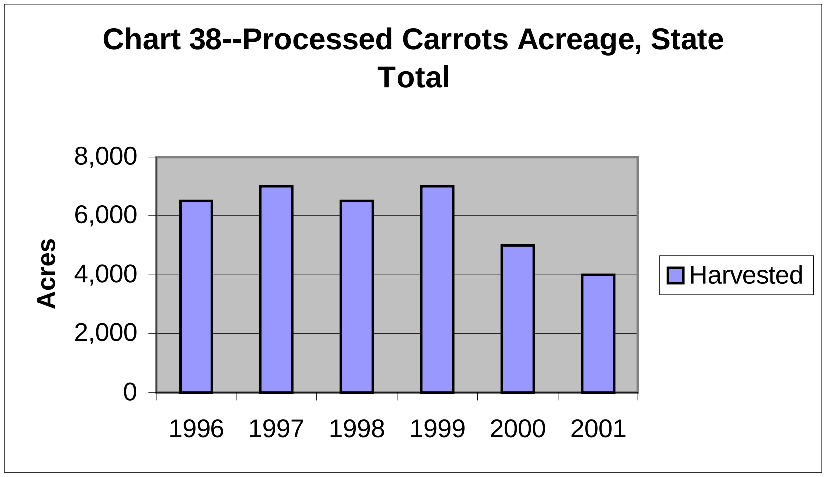






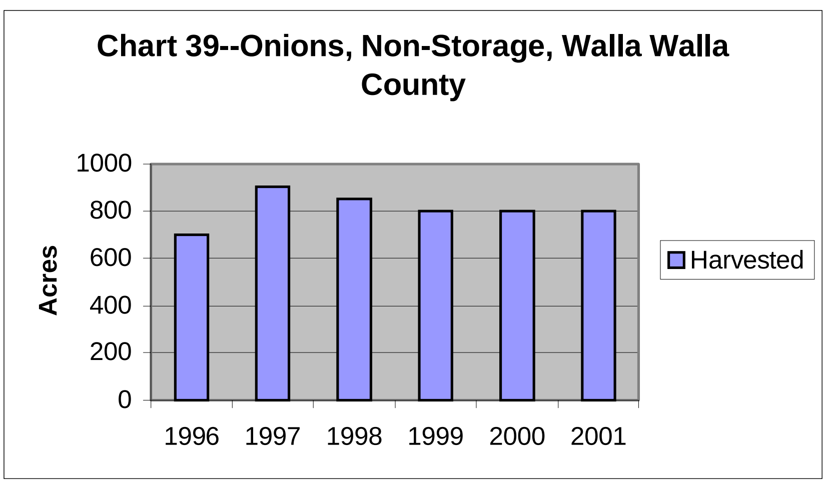
Processed Carrots

The trend is generally downward for harvested acreage of processed carrots, as exhibited by the state total. County level acreage is generally downward as well. Benton, Franklin, Grant, and Klickitat counties account for all of the processed carrot acreage in Washington. Only the state total harvested acreage is displayed below in Chart 38.



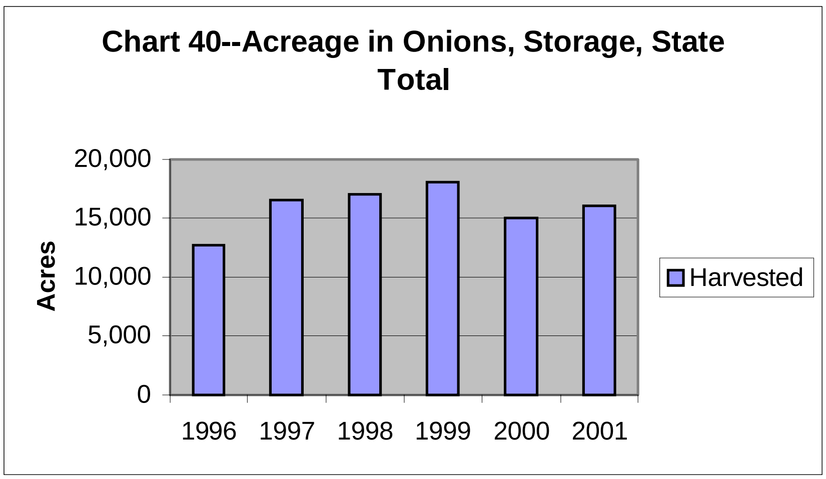
Onions, Non-Storage

Non-Storage Onion growth occurs in only one county in the state, Walla Walla County. There is no apparent trend in this crop, displaying fairly steady production in the late 1990s and through 2001.



Onions, Storage

Acreage in storage onions is rather steady as well, no lower than 15,000 acres since 1996, and up from 2000 to 2001 during a drought year. County trends exhibit similar patterns, with slight downward trends in Adams, Benton, and Grant counties, and a large upward trend in Walla Walla County. Adams, Benton, Franklin, Grant, and Walla Walla counties accounted for nearly 97% of the harvested acres in storage onions.



Sweet Corn, Processed

There is a strong upward trend in processed sweet corn in the late 1990s, leveling off just below 100,000 acres since 1998. Counties relevant to the Columbia River accounted for 92% of the harvested acres in processed sweet corn in 2001. State totals, and all counties with available data are shown in the charts below.

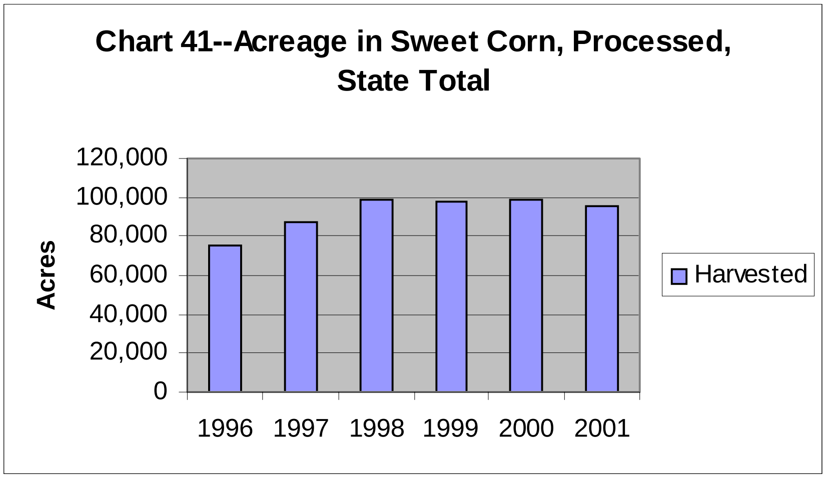


Chart 41--Acreage in Sweet Corn, Processed, State Total
Acres
120,000
100,000
80,000
60,000
40,000
20,000
0
1996
1997
1998
1999
2000
2001
Harvested

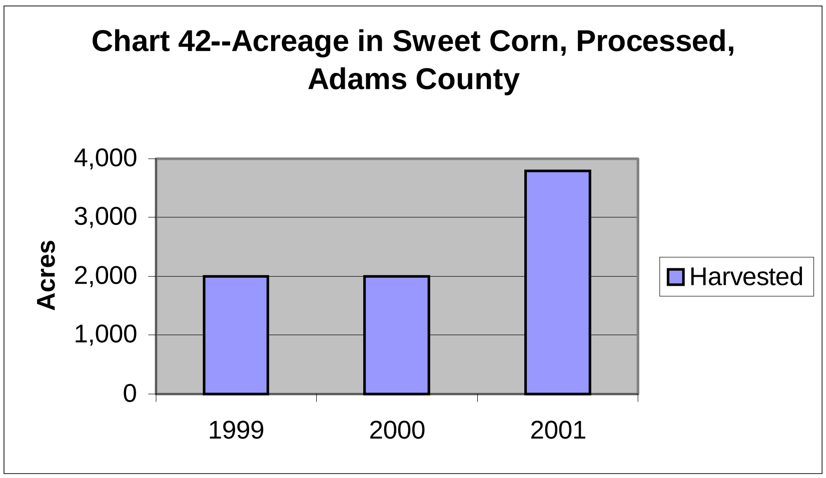


Chart 42--Acreage in Sweet Corn, Processed, Adams County
Acres
4,000
3,000
2,000
1,000
0
1999
2000
2001
Harvested

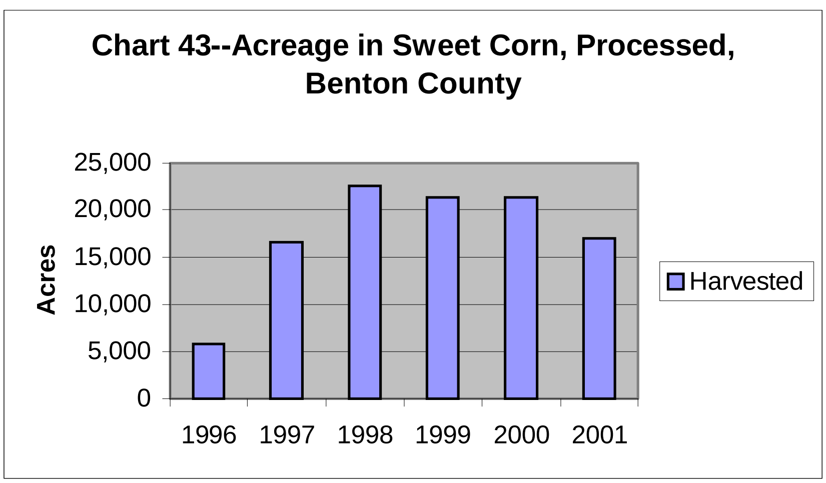


Chart 43--Acreage in Sweet Corn, Processed, Benton County
Acres
25,000
20,000
15,000
10,000
5,000
0
1996
1997
1998
1999
2000
2001
Harvested

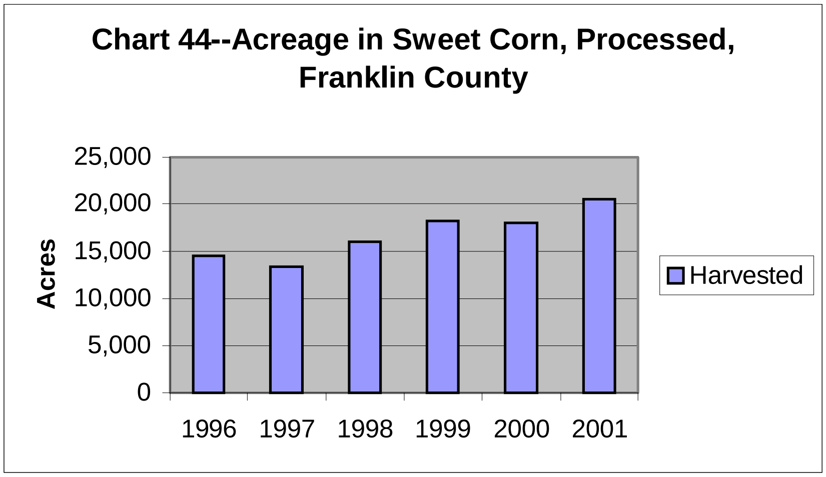


Chart 44--Acreage in Sweet Corn, Processed, Franklin County
Acres
25,000
20,000
15,000
10,000
5,000
0
1996
1997
1998
1999
2000
2001
Harvested

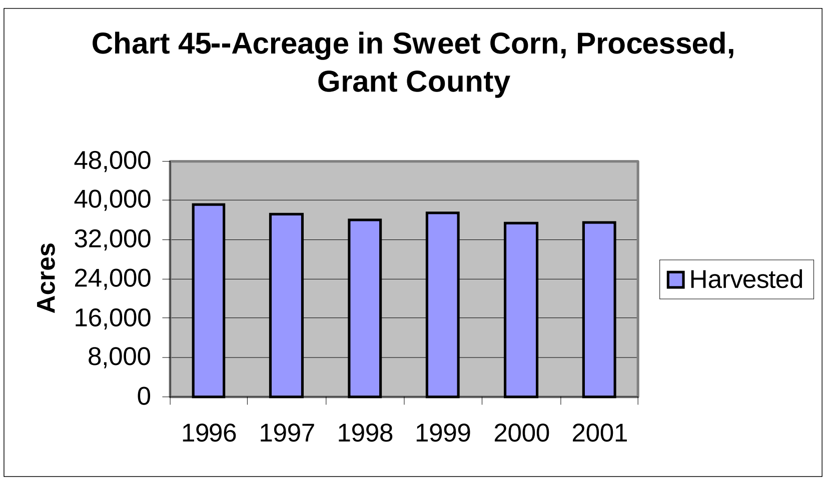


Chart 45--Acreage in Sweet Corn, Processed, Grant County
Acres
48,000
40,000
32,000
24,000
16,000
8,000
0
1996
1997
1998
1999
2000
2001
Harvested

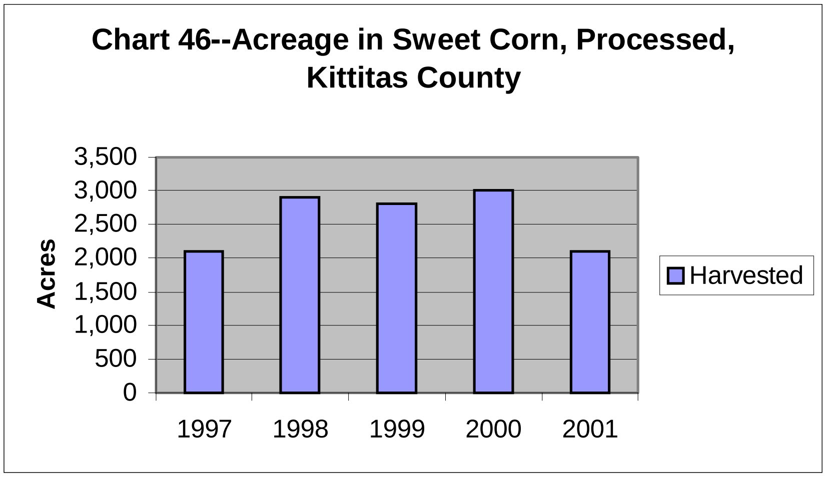


Chart 46--Acreage in Sweet Corn, Processed, Kittitas County
Acres
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1997
1998
1999
2000
2001
Harvested

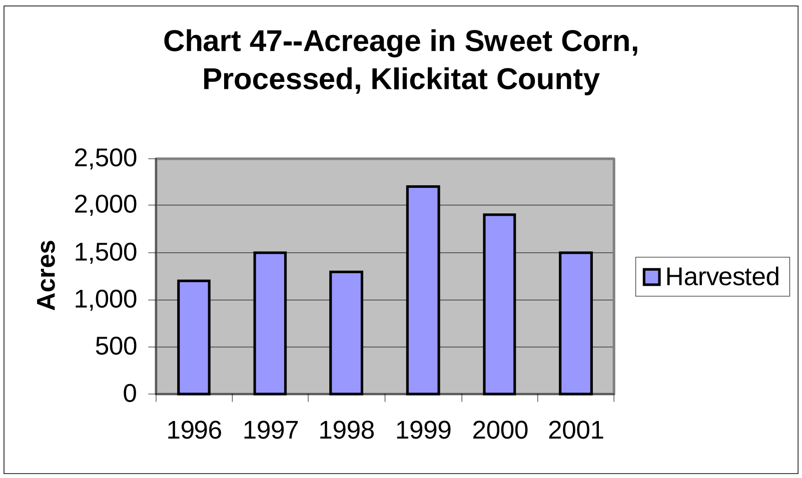


Chart 47--Acreage in Sweet Corn, Processed, Klickitat County
Acres
2,500
2,000
1,500
1,000
500
0
1996
1997
1998
1999
2000
2001
Harvested

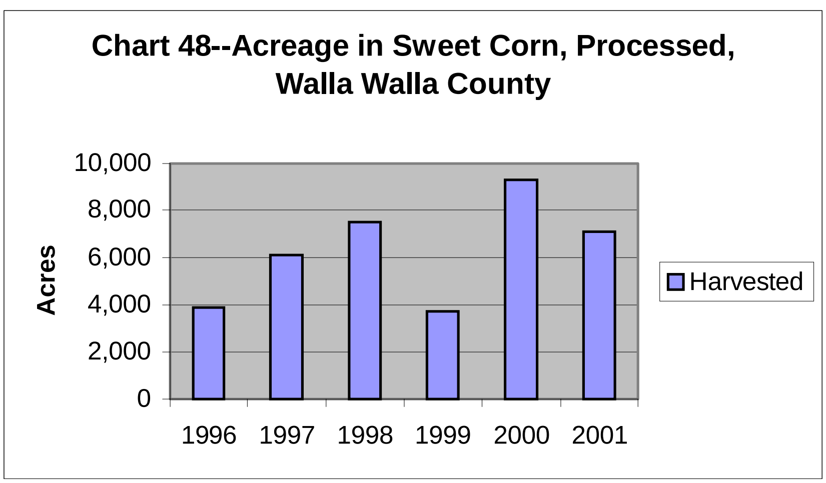
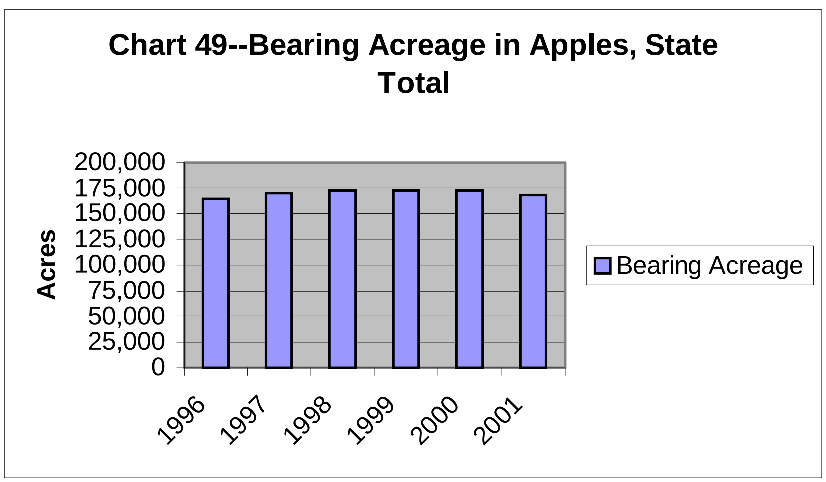


Chart 48--Acreage in Sweet Corn, Processed, Walla Walla County
Acres
10,000
8,000
6,000
4,000
2,000
0
1996
1997
1998
1999
2000
2001
Harvested

Apples

Bearing acreage in apples exhibits an upward trend in the late 1990s through 2000, and down from 2000 to 2001 in Washington State. County level data is not available. In 2001, WASS put out a Fruit Tree Survey report that provides valuable information on the trend in variety of apples covering data through 2000. More recent evidence suggests that this survey may already be out-dated as productions seems to be shifting away from Red Delicious varieties and into other varieties such as Fuji, Gala, and Braeburn. Chart 49 shows State total bearing acreage in recent years, while charts 50 through 53 show the evolution of production by variety since the early 1980s.



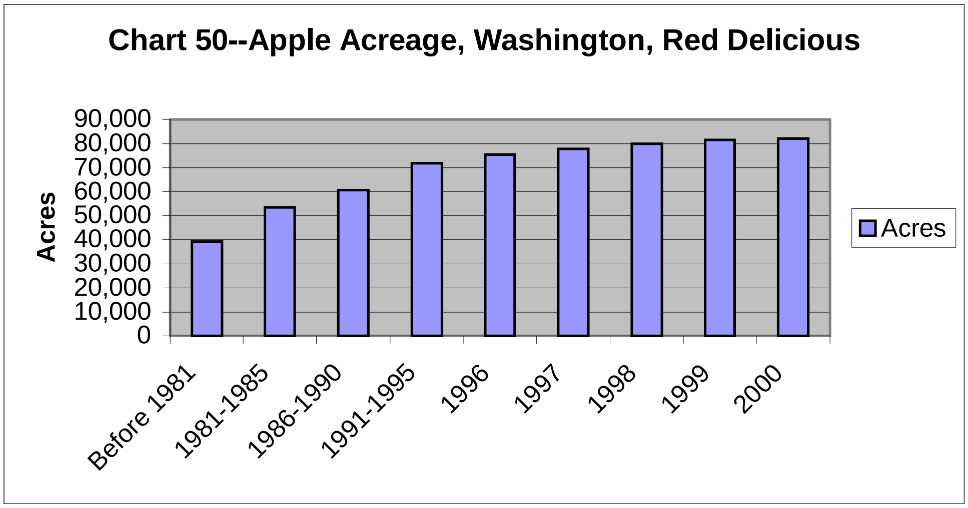


Chart 50--Apple Acreage, Washington, Red Delicious
Acres
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Before 1981
1981-1985
1986-1990
1991-1995
1996
1997
1998
1999
2000
Acres

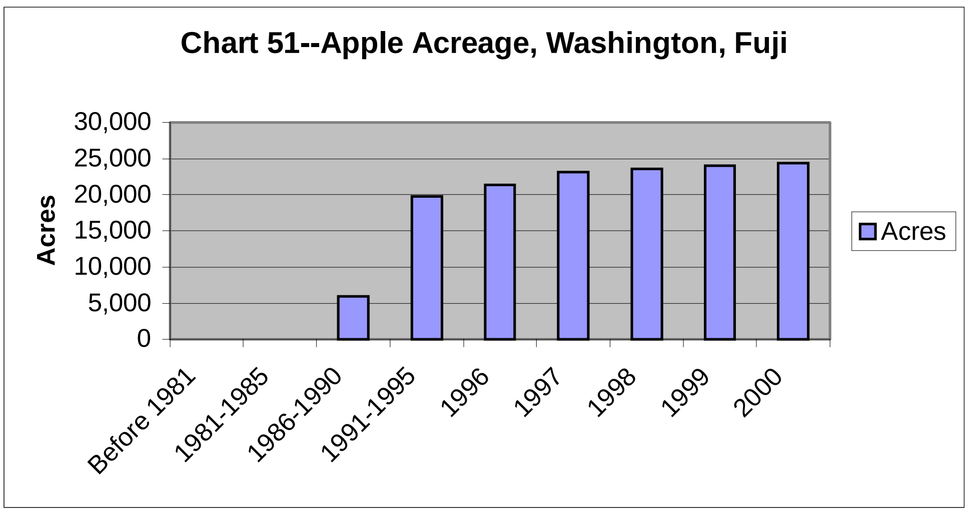
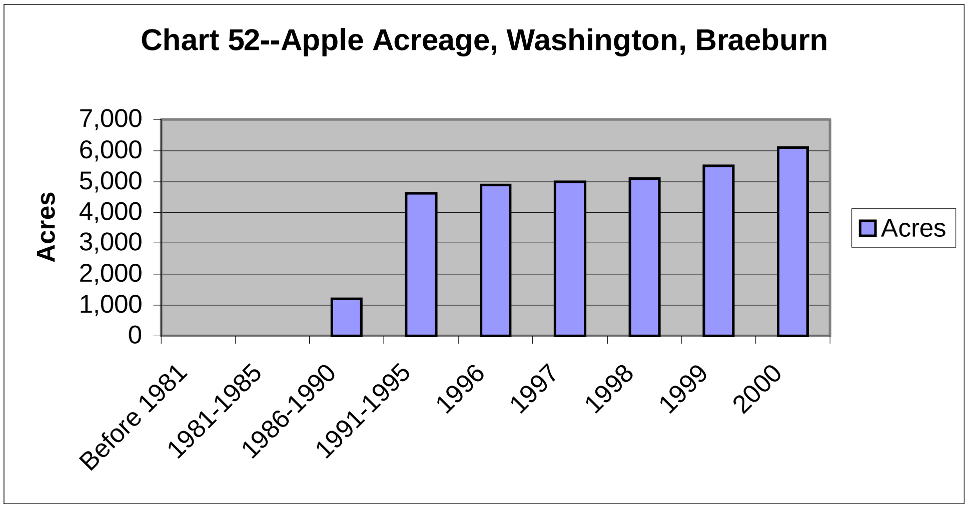
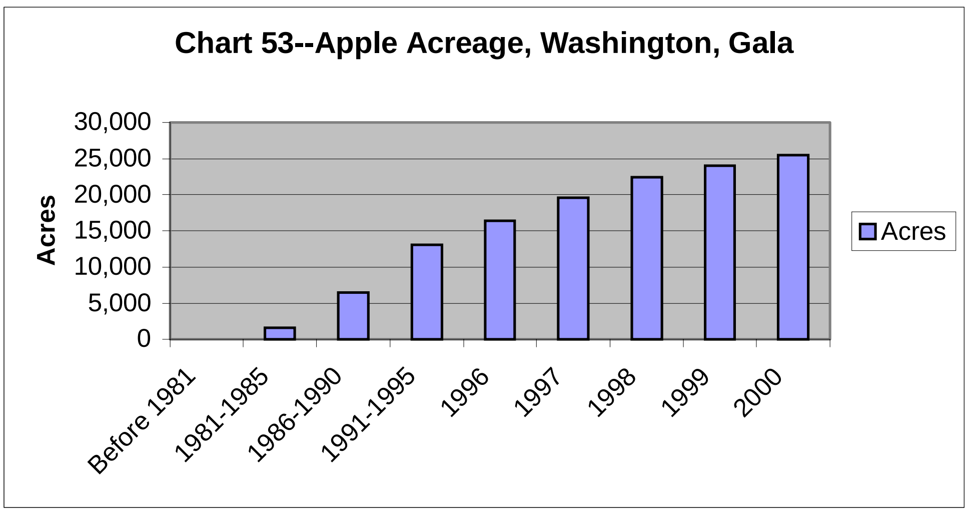


Chart 51--Apple Acreage, Washington, Fuji
Acres
30,000
25,000
20,000
15,000
10,000
5,000
0
Before 1981
1981-1985
1986-1990
1991-1995
1996
1997
1998
1999
2000
Acres

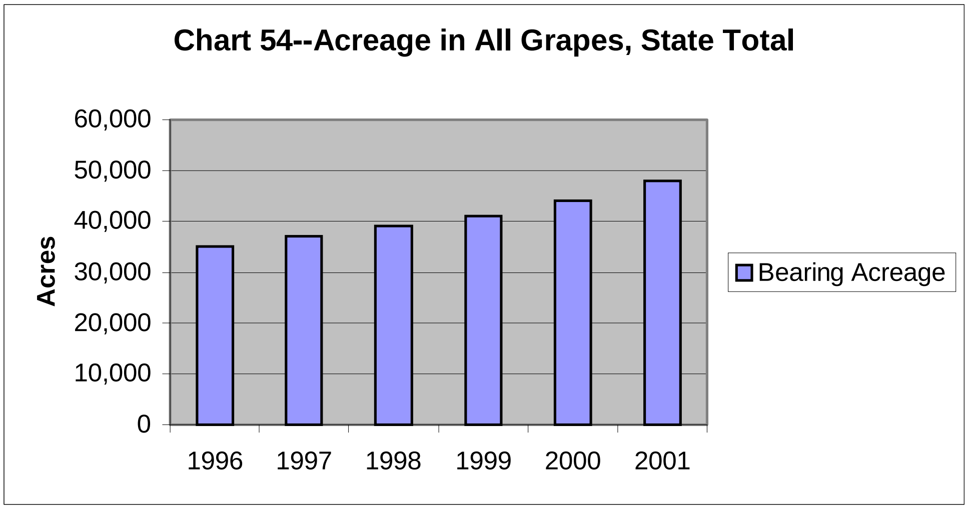


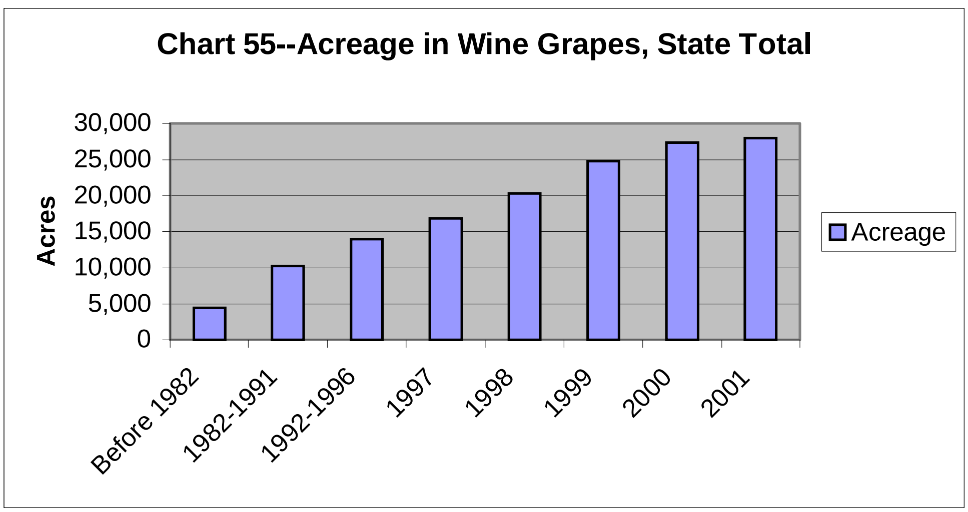


Grapes

Perhaps the strongest upward trend in any Washington crop occurs in grapes. The trend is continuously upward from 1991 through 2001. Washington was the nation's second highest producer of grapes, behind California. One contributing factor to this strong upward trend is the emergence of wine grapes in Washington State. WASS released a report on wine grape acreage in 2002. Wine grape acreage is broken down by American Viticulture Area (AVA), many of which are relevant to the Columbia River, including Columbia Basin, Walla Walla, Red

Mountain, and Yakima Districts. The charts below show state totals of recent acreage trends, and the evolution of wine grape acreage in AVAs since the early 1980s. It is most likely that the water diverted for irrigation in the last AVA shown, Yakima, comes from the Yakima River rather than the Columbia River.





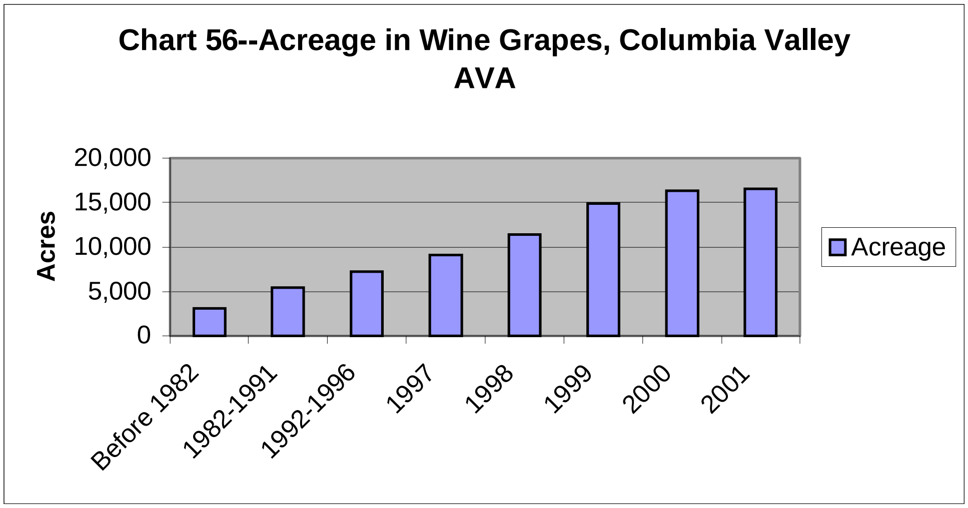


Chart 56--Acreage in Wine Grapes, Columbia Valley AVA
Acres
20,000
15,000
10,000
5,000
0
Before 1982
1982-1991
1992-1996
1997
1998
1999
2000
2001
Acreage

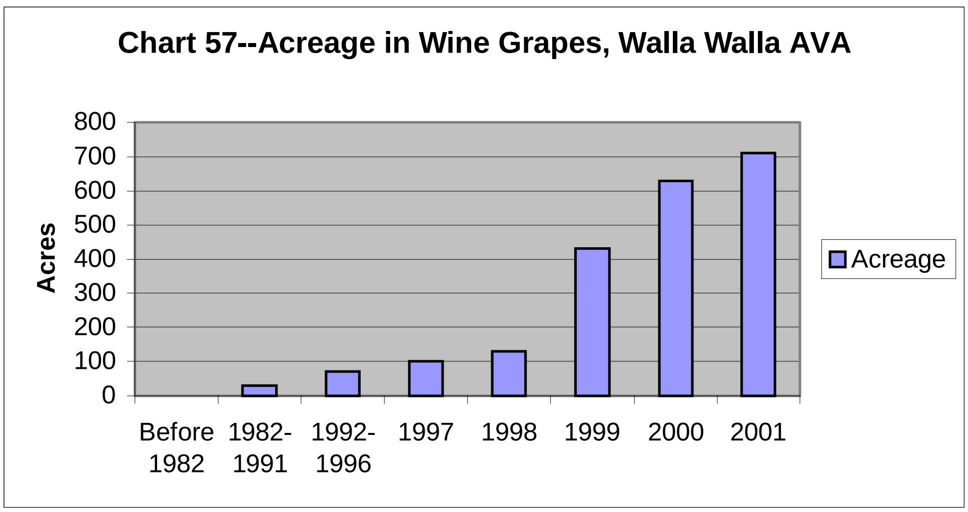
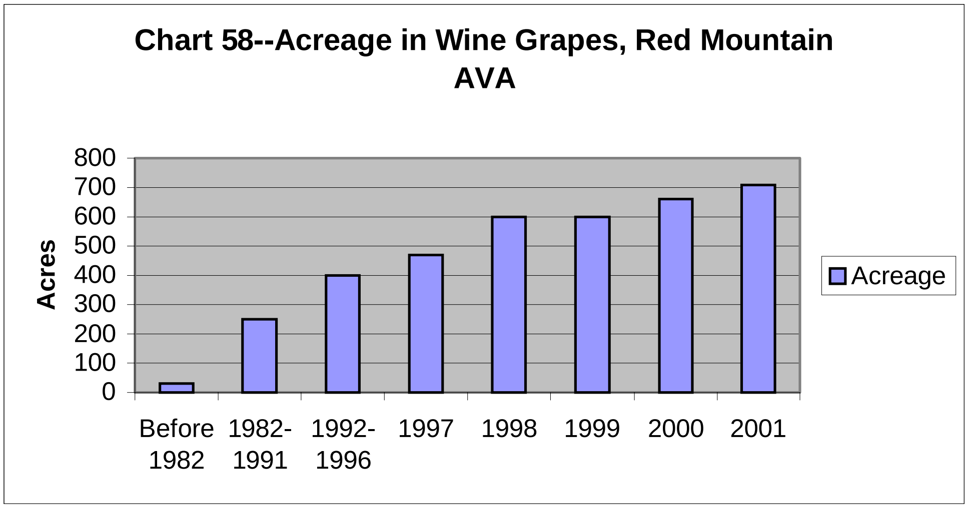
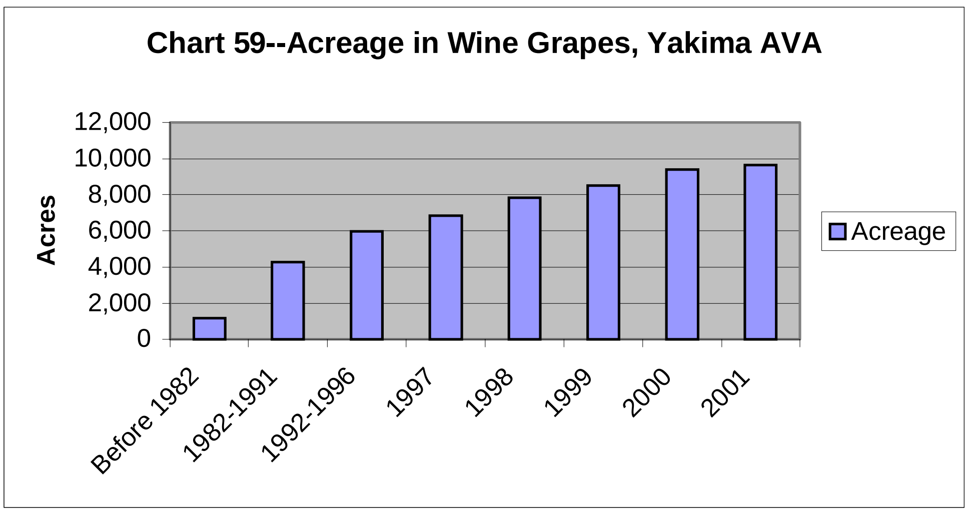


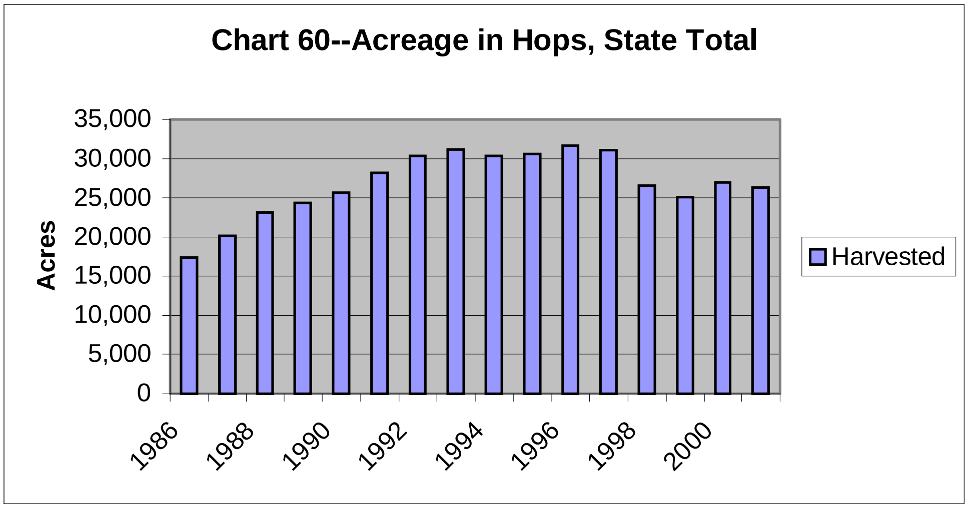
Chart 57--Acreage in Wine Grapes, Walla Walla AVA
Acres
800
700
600
500
400
300
200
100
0
Before 1982
1982-1991
1992-1996
1997
1998
1999
2000
2001
Acreage





<u>Hops</u>

Harvested acres in hops picked up in the late 1980s with the emergence of microbreweries. However, more recent trends suggest that acreage has leveled off and perhaps is falling. Chart 60 shows the trend in harvested acreage for hops from 1986 to 2001. County level data is not available for hops from WASS.



Conclusion

In summary, the purpose of this appendix is to answer the question: If additional water were diverted from the Columbia River, what crops would be produced? The key to answering this lies in the trend in irrigated acreage. Long-term trends have been examined at the county level, as well as more recent trends on a crop by crop basis. Unfortunately, comparable irrigated acreage data is not available after 1997, so exact trends in irrigation are hard to determine. The strongest upward trends in recent years appear most notably for grapes, and certain types of apples, such as Fuji, Gala, and Braeburn. The strongest downward trends appear for grains such as wheat, barley, and oats. For still other crops, no trend appears obvious, such as potatoes, vegetables, and hops.